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Report of the Southeastern Conference on Biology Teaching

August 28 - September 6, 1954 Gainesville, Florida

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COVER PHOTOGRAPH

The University Auditorium, University of Florida, Gainesville makes an interesting photograph. Picture by Photo Service, University of Florida.

THE AMERICAN BIOLOGY TEACHER

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THE NATIONAL ASSOCIATION OF BIOLOGY TEACHERS

Report of the

SOUTHEASTERN CONFERENCE ON BIOLOGY TEACHING

held at
University of Florida
Gainesville, Florida

AUGUST 28 - SEPTEMBER 6, 1954

Conducted by

THE NATIONAL ASSOCIATION OF BIOLOGY TEACHERS
in cooperation with
The American Institute of Biological Sciences
Supported by a grant from
The National Science Foundation

The Staff in conference: Seated: Jeffers, Bingham, Stickler. Standing: Weaver, Meyer.

PREFACE

During the past sixteen years the National Association of Biology Teachers has been devoted to the improvement of biology teaching in high schools and colleges. Through national, regional, and local affiliated group meetings, through the publication of *The American Biology Teacher*, and through active committees working in all regions on the various segments of this problem, the work has gone forward with a considerable degree of success. Since the membership is representative of both high school and college teachers, a community of interest and understanding has developed and the unfortunate barriers between these two levels have weakened to a heartening degree.

Biology teachers have profited widely from the Association's service in bringing together and making available new techniques, sources of teaching materials, screening and evaluating films and literature, and in developing among its members a heightened professional spirit. Some of its committees, such as those on health education and conservation education, have worked with state and local sub-committees so as to reach classroom teachers even in remote areas. The Committee on Conservation Education, under the direction of Dr. Richard L. Weaver, has recently completed a three-year nationwide study of what is actually being done in teaching conservation of our natural resources in the public schools. A grant of $10,000 by the American Nature Association made it possible to secure wide participation in every state and to bring together the results in a report that has just appeared under the title *Handbook on Teaching Conservation and Resource Use.*

In December, 1953, The National Association of Biology Teachers presented to the National Science Foundation a proposal for a series of annual regional work conferences on the teaching of biology. It was proposed that the participants be selected from school and college teachers of biology, specialists in the several areas of biological sciences, specialists in teacher education, and administrative personnel from local, county and state departments. The idea of having these various representatives, all of whom contribute to the common aim of better biology teaching, sit down together and plan "the best plays for

the team" was somewhat novel and appealed to many as promising effective results.

In May, the National Science Foundation, in response to the proposal, announced a grant of $15,000 to finance a ten-day work conference to be held on August 28-September 6 at Gainesville, Florida, preceding the annual convention of the American Institute of Biological Sciences, of which body the National Association of Biology Teachers is an affiliate member.

A planning committee met in Washington, D. C., on June 1-2 to outline the general course of preparation for the Work Conference. A Steering Committee was selected to determine the policies for the project. This Committee named the following staff charged with selecting participants and planning details of the program:

- Richard L. Weaver, Co-Director, University of Michigan
- Samuel L. Meyer, Co-Director, Florida State University
- Ned Bingham, University of Florida
- George Jeffers, Longwood College
- W. Hugh Stickler, Florida State University

To Dr. Meyer and particularly to Dr. Weaver belongs much credit for their work in organizing the program and bringing together a splendid roster of participants.

Members of the Steering Committee were:

- Harvey E. Stork, Chairman, Carleton College, Northfield, Minnesota
- Muriel Beuschlein, Secretary, Chicago Teachers College, Chicago, Illinois
- Arthur Baker, President, NABT, Crystal Lake, Illinois
- Hiden T. Cox, American Institute of Biological Sciences
- Samuel Duncan, North Carolina Dept. of Education, Raleigh, N. C.
- Leo Hadsall, Fresno State College, Fresno, California
- George Jeffers, Longwood College, Farmville, Virginia
- W. Edgar Martin, U. S. Office of Education, Washington, D. C.
- Samuel L. Meyer, Florida State University, Tallahassee, Fla.
- E. L. Palmer, National Wildlife Federation, Washington, D. C.
- H. M. Phillips, Emory University, Atlanta, Georgia
- Malvina Trussell, Florida State University, Tallahassee, Fla.
- Richard L. Weaver, University of Michigan, Ann Arbor, Mich.

The following staff assistants were named to work with the above Committee in Gainesville:

- Richard R. Armacost, Co-editor, *American Biology Teacher*, Purdue University
- John Breukelman, Vice-President, NABT, State Teachers College, Emporia, Kansas
- Brother H. Charles, President-Elect, NABT, St. Mary's College, Winona, Minnesota
- Ruth Dodge, AIBS representative, Emma Willard School, Troy, New York
- Robert Gering, Associate Managing Editor, ABT, Wells College, Aurora, New York
- Paul Webster, Secretary, NABT, Bryan, Ohio.

The Publications Committee responsible for compiling this report was under the co-chairmanship of John Breukelman and Richard Armacost. The other members are Samuel L. Meyer, W. Hugh Stickler and Richard L. Weaver.

HARVEY E. STORK
Chairman, Steering Committee

Introduction

OBJECTIVES OF THE CONFERENCE

Four major objectives were agreed upon by the staff and Steering Committee of the conference. They were:

I. Establish the proper role and major contributions of the fields of morphology, taxonomy, physiology, evolution and paleontology, genetics, ecology and conservation in the training of biology teachers.

II. Identify and select some of the major problems found in:
   a. the teaching of high school biology
   b. the teaching of college biology
   c. establishing a state-wide program or emphasis on biology teaching.

III. Develop suggestions and recommendations for:
   a. the improvement of biology teaching in high school
   b. the improvement of biology teaching in college with particular reference to teacher training
   c. greater emphasis on biology teaching, at the state level.

IV. Provide for preparation of state plans for implementation of the recommendations of the Conference, and have a review panel of state department of education representatives to assist in the evaluation of the proposals.

SELECTION OF PARTICIPANTS

Teams of participants were selected in the ten southeastern states from lists nominated by the State Superintendent of Public Instruction and members of his staff, in each state.

Each team was composed of one or two high school teachers, two to four college teachers of biology and/or science education, one to two administrators from colleges, public schools, or state departments of education.

ORGANIZATION AND CONDUCT

Part I

Six biological scientists prepared written summary statements showing how their special fields could and should contribute to the training of biology teachers. The six scientists met in two-hour sessions with each of six groups during the first three days of the conference. With the help of a recorder who accompanied the scientist, a summary of the reactions of the participants to the prepared statements was made for each of the subject matter areas of biology covered.

Part II

All participants were distributed in four discussion groups so that each group consisted of persons from each state and from each area of instruction or administration.

The problems of teaching biology in high school and college, and in developing a state-wide emphasis on biology were described prior to the conference in a series of written papers prepared by fifteen of the participants. These are summarized in this report, but the original papers formed the basis for identification and selection of problems to be considered at the conference. Part II of the conference, dealing with problem identification and selection, required a day and a half. Twenty problems were chosen for consideration from the sixty or more which were identified.

Part III.

The same work groups of Part II were retained for Part III of the conference. Two days were devoted to preparing recommendations on each of the twenty problems chosen. Reports from each of the four groups were duplicated and distributed to all participants in the conference.

Part IV

A Review Panel composed of state superintendents of public instruction, staff members of state departments of education and college or public school administrators reviewed the recommendations of the four groups on each of the twenty problems. They indicated whether or not they felt the recommendations or plans of action could be carried out. In the view of their reactions, and further discussion of the plans by the participants, generally, members of the staff compiled the set of recommendations included in this report.

STATE TEAMS

Each of the state teams met one or more times and prepared plans for implementing the recommendations of the conference in their states. A summary of these plans is included in this report.

CONFERENCE EVALUATION

An oral evaluation was conducted at the conclusion of Part I of the conference. A written evaluation was made at the last session of the conference, supplemented by a discussion of ways and means of strengthening similar conferences.

RICHARD L. WEAVER
Co-director

SAMUEL E. MEYER
Co-director

PART I Some Contributions of Certain Areas of Biology to the Training of Biology Teachers

Heredity and Development

HERBERT PARKES RILEY
Head, Department of Botany
University of Kentucky

A study of heredity and development can contribute greatly to the training of a biology teacher by making him aware of the principles of biological inheritance, of

the factors involved in development and of the interrelation between development and heredity. The teacher should familiarize himself with the basic laws of Mendel, with the extension of those laws to cover more complex situations, with the physical basis of heredity and the structure, chemical nature and behavior of the chromosomes and with the principles of variation, its occurrence in nature and its measurement. Other noteworthy principles and generalizations are the theory of the gene, the nature and importance of polygenes and the role of plasmagenes in heredity. Of great value in the training of biologists would be a description of some of the traits found to be inherited in human beings and some information about the methods which have been used to determine their hereditary basis. Generalizations and theories important to a knowledge of development are: the folding of tissues and the migration of cells during the embryology of the animal; the differentiation of germ layers in animals and the differentiation of plant cells from meristematic tissues; the importance of hormones and of other biochemical substances produced during development as understood from the transplantation of eye primordia in *Drosophlia;* the nature of genetic blocks in chains of chemical reactions during the development of plants and animals; organizers and axial gradients; heterogonic growth; the germ layers and the development of the leaf and flower as demonstrated by induced chromosomal periclinal chimeras.

Since the laws of heredity have been learned from experiments conducted on both plants and animals, training in genetics will tend to give a teacher of biology an insight into the unity of life. Not only do fundamental principles and the physical basis of heredity operate in the same fashion in both Kingdoms, but also the nature of gene action is very similar in both animals and plants. Therefore, the teacher who is trained in genetics is more likely to visualize the field of biology as one big field rather than as two largely unrelated disciplines, zoology and botany. Within recent years, too, studies on *Neurospora*, bacteria, yeast, *Paramecium* and other lower organisms have been extensive. By showing that the same laws govern both the simple and the more advanced forms of life, studies in heredity well illustrate the unity of life and the basic similarity of all plants and animals.

A study of genetics and development leads to a better understanding of cellular organization and the cellular basis of life. Generalizations which aid in an understanding of these principles are the elaborate mechanism of mitosis which ensures that the daughter cells receive the same number of chromosomes as one another and as the cell which divides to produce them, the self-duplication of proteins, the reproductive capacity of cell constituents such as chromosomes, genes and mitochondria, and the constancy of the chromosomes from one cell generation to another.

In recent years, experiments on *Drosophila* transplants and on *Neurospora* and other lower plants have yielded considerable information as to the inheritance of fundamental biochemical processes. These studies have also led to a better understanding of biochemistry in general and could well contribute to the training of a biology teacher. A discussion of biochemical processes shows that they are under the control of genes and that many of

these processes are absolutely essential to life; that genetic blocks can arise by mutation which interrupt the chain of chemical reactions; and that some fundamental biochemical reactions in humans are under genetic control and certain people who have mutant genes are unable to carry out certain important chemical syntheses.

Although the earlier work in genetics dealt with higher plants and animals almost exclusively, numerous studies on lower organisms have been carried out during the last fifteen years. Coupled with important cytological observations, they have increased greatly our knowledge of reproduction, life cycles, and cellular structures in these lower forms. Items of general interest to the biology teacher would be sexual reproduction in bacteria and yeast, the bacterial nucleus, the nucleus and cellular structure of yeast, and mitosis in lower organisms.

While problems of speciation and hybridization may be discussed in the section on Evolution and Paleontology, they involve the hereditary mechanism and can appropriately be taken up here, also. They involve such topics as gene mutation, polyploidy and other chromosomal aberrations, hybridization between species, and the importance of allopolyploidy in rendering hybrids fertile. Isolating mechanisms and the appearance of hybrid swarms can be studied in this group as well as in the group on evolution.

A biology teacher should be prepared to discuss the age-old problem of heredity and environment. It should be pointed out that this problem is no longer pertinent and that it is replaced today by a study of the action and effects of different genes acting in different environments, for the developed character is the result of the cooperation of the genotype, the cytoplasm and the environment all operating together during the development of the individual. Phenocopies could be introduced in this discussion.

Since the explosion of the first atomic bomb, great interest has centered around the effects of radiation on living organisms. Courses in genetics should be helpful as they frequently discuss the effects of radiation on the hereditary mechanism and include topics such as the induction of gene mutations, both lethal and visible, the production of various types of chromosome aberrations, the hazards of overdoses of radiation and the use of radiation in the treatment of cancer.

Finally, genetics courses help to dispel some of the old notions which have no scientific basis. These "old wives' tales" die hard. Under this point might well be discussed the inheritance of acquired characters, biogenesis, telegony, and maternal impressions, including the difference between maternal impressions in the old sense and the effect of the placental environment of the child.

Recorder's Report of Discussion on HEREDITY AND DEVELOPMENT

There is a body of subject matter called biology. It is neither botany nor zoology. Genetics is a biological subject. Training in genetics can therefore be of great value to a biology teacher. It can help to give a teacher a perspective of biology as a unified whole.

An understanding of mitosis and meiosis is fundamental to an understanding of genetics. The chromosomes and their mitotic activity should be studied rather carefully. Meiosis is a much more complex process than mitosis, and though certain aspects such as reduction and crossing over need to be known thoroughly, care should be exercised in the selection of the remaining material which is presented. Life cycles are important and need to be stressed. Internal and external environments should be recognized and carefully considered when studying the characteristics of organisms.

After the study of the cell and its activities, certain other areas of genetics seem to represent a *minimum* of *recommended* knowledge:

1. Mendel's basic laws (monohybrid, dihybrid ratios).
2. Polyhybrids—trihybrids, etc. gives the student some conception of the mathematics on which genetics is based.
3. Sex inheritance and sex linkage—mostly an animal approach.
4. Linkage and crossing over: genes on chromosomes; linear order; an appreciation of linkage.
5. Mutations and the mutation process. The action of genes. Genes are not entirely stable.

6. Biochemical genetics. Shows the mutual relationships between chemistry and genetics.
7. Polygenes—quantitative characters; interaction of genes.
8. Radiation effect on hereditary mechanism —speeds up process; not new, repetition of same things already discovered in nature.
9. Population genetics—not very deeply, because of mathematical requirement.
10. Human genetics and eugenics.

Genetics for high school teachers can be descriptive as opposed to mathematical and quantitative.[1] This does not mean that teachers should not be given some of the statistical treatment so important to the field, but that the amount and kind of mathematics should be tempered with the needs and abilities of the students kept in mind. A minimum is represented by insisting that teachers have the opportunity to see examples of the statistical treatment used in genetics—whether or not they can use or entirely understand the processes.

A few other suggestions seem to be in order:

1. Teachers should be careful not to oversimplify explanations to their students, particularly in such critical and somewhat complex areas as human genetics.[2] "The easiest way to confuse a student is by lack of information."

2. Laboratory is helpful in the study of genetics, but not an absolute essential. It is helpful and probably essential that teachers and students see chromosomes, and demonstrations of fruit flies, biochemical inheritance (*Neurospora*), P. T. C. taster leaflets, etc.

Analysis of human family histories, and study of newspaper clippings concerned with genetics are worthwhile activities, as is the field trip to a greenhouse, museum, or places outside the school building where variation genetic and environmental) can be seen in many plants and animals.

3. Genetics can explain and remove many false ideas. Misconception and prejudice often go hand in hand.

4. The history of genetics can be effectively integrated into the total genetics course.

5. A basis can be provided to understand practical plant and animal breeding.

6. The study of development can involve such knowledge as the folding of tissue and the migration of cells during the embryology of the animal; the differentiation of germ layers in animals; the differentiation of plant cells from meristematic tissues; the germ layers and the development of leaf and flower.

7. Science is not final nor are so-called authorities in science final.

RICHARD R. ARMACOST
Recorder

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[1]Two high school teachers in Group III felt rather strongly that the amount of mathematics that high school students can absorb had been underestimated. This, however, was not the general opinion. These two teachers were commended and encouraged to teach as much mathematics in their biology courses as they found useful and possible.

[2]One member of Group I felt strongly enough on this subject to support the idea that it would be better to have no genetics at all rather than only the superficial treatment which is frequently given in the survey type of general education biology.

Evolution and Paleontology

LOREN C. PETRY
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Cornell University

A. *Introduction*

1. Scientists make two fundamental assumptions:
   a. that the universe as a whole displays order.
   b. that man has reached a sufficiently advanced stage in his own evolution to enable him to examine, interpret, and understand that order.

2. Biologists are scientists concerned with the order displayed by matter in the living condition.

3. Living matter is distinguished from non-living matter principally by three characteristics:
   a. growth and reproduction.
   b. respiration.
   c. cellular structure.

4. In their efforts to understand the order displayed by living matter, biologists have concerned themselves principally with three questions:
   a. how are organisms constructed, and how do they operate?
   b. what kinds of organisms are there, and how did they originate?
   c. how are organisms distributed over the earth, and how do they maintain themselves there?

5. In their efforts to answer the *second* of these questions, biologists have engaged in three principal lines of activity:
   a. assigning names to organisms.
   b. arranging organisms in groups.
   c. explaining and justifying the arrangements.

6. In their efforts to make and justify arrangements of organisms, biologists have made three principal assumptions:
   a. that relationship or common ancestry is the principal valid explanation of similarity of organisms.
   b. that the changes in organisms which are associated with reproduction and produce dissimilarities are cumulative in effect and sufficient in magnitude to have caused all the known differences in organisms within the known period of life on the earth.
   c. that conditions on the surface of the earth in the past have been essentially the same as at present, unless there is definite evidence to the contrary.

B. *Fundamental concepts of organic evolution.*

1. The earth originated in some undetermined way, probably by separation from the sun, some three or four billion years ago.

2. At some subsequent time living matter originated on the earth from non-living matter. Living matter may have originated repeatedly.

3. Nothing is known about the method of origin of living matter. It is assumed that the original living matter was simple in structure.

4. The original living matter either possessed or acquired the ability to undergo transmissible (heritable) changes in structure and/or function.

5. As a result of such changes, the original kind of living matter presently became many kinds. These many kinds, differing structurally or functionally or both, are called species, varieties, etc. The individuals are called organisms.

6. Early organisms were all simple in structure; that is, they consisted of few kinds of parts.

7. Most of the changes which occurred produced either no change in complexity of structure, or simplification; a small fraction of the changes produced an increase in structural complexity.

8. Similar changes in functional complexity occurred.

9. At first all organisms fitted to their physical environment survived. As the number of organisms and of kinds of organisms increased, a competition between organisms and between kinds of organisms developed.

From this time on survival has depended on adjustment to both physical and biological environment.

10. A fraction of the organisms produced by the changes resulting in an increase in structural and/or functional complexity have possessed especially effective adjustments to one or several of the environmental factors surrounding them.

11. Each such change has resulted in the development of a new group of organisms possessing the advantageous new character. Illustrations are:

a. the development of pigments able to absorb energy from light resulted in the development of green plants.
b. the organization of the genic material into a definite nucleus occurred in the ancestral forms of all groups of organisms except the bacteria and blue-green algae.
c. the development of the particular kind of fruit called an acorn was the origin of the trees grouped in the genus *Quercus*.

12. Changes involving no significant change in complexity were much more common than those involving an increase in complexity. These account for the greater part of the diversity of organisms. An illustration is:

a. the beech nut and hazel nut are not significantly simpler or more complex than the acorn, but they are different, and form the bases for two other genera of woody plants.

13. Changes involving simplification were common and the resulting organisms, in most cases, did not survive. There are abundant important exceptions, frequently associated with significant changes in habitat. An illustration is:

a. *Spirodela*, *Lemna*, and *Wolffia* are vegetatively simple plants living in water. They probably originated from one of the terrestrial Araceae, whose flowers, fruits, and seeds are very similar.

14. Changes in the methods of reproduction have been of particular significance. Such changes soon resulted in adding two significant new functions to the reproductive process.

a. increased multiplication.
b. distribution.

15. The original method of producing new cells by division was eventually supplemented by the new method of fusion of cells. This method of sexual reproduction produced a significant increase in the rate at which changes occur in the resulting organisms.

16. Geographical and/or genetic isolation, or the lack of it, became important factors in determining the rate at which new species were developed.

17. The development of two kinds of gametes provided important functional advantages and increased the probability of survival of organisms producing them.

18. Examples of the many similar modifications of reproductive structure and function in plants are:

a. development of aerial spores in fungi.
b. transfer of sperms through a pollen tube.
c. insect pollination.

19. Changes in vegetative structures were of substantially equal significance. Examples are:

a. the appearance of stomata permitted the development of land plants of considerable size.
b. The development of vascular tissues in plants resulted in the evolution of large long-lived trees.

C. *Concepts and information contributed by paleontology.*

1. Fossils are natural objects which furnish useful information about the structures and functions of specific organisms of the past.

2. The uranium-lead ratio method of determining the age of rocks makes it possible to be sure of the age of the organisms represented by fossils and so of the order of their occurrence.

3. The earliest organisms were all simple in structure.

4. More complex organisms appeared approximately in the order of their complexity.

5. Few species or genera survived for any great length of time; but few important groups died out without leaving more complex modified descendents.

6. The process of evolution has been continuous.

7. The rate of evolution has varied greatly from group to group.

8. The rate of evolution in particular groups has varied greatly from time to time.

9. All organisms of the present time are the products of an evolutionary process which has been operating from one and one-half to two billion years.

10. The protoplasm of all present-day organisms may be assumed to be more complex in both structure and function than the original living matter out of which all organisms have developed.

D. *Generalized Statement*

1. From a single, original form of life, or from a relatively few original forms, of very simple organization, other forms of greater complexity have in some manner been developed.

2. From these forms still others, mostly of greater complexity, but sometimes of simpler organization, have been developed in the same manner.

3. This process has continued at varying rates but without interruption from the time of beginning of life on the earth to the present time, and is now going on.

4. All known organisms, both extinct and living, both plant and animal, have arisen in this way.

E. *Significance of some of these concepts for the teacher of biology.*

1. *Time* is an undefinable term whose meaning is learned naively in infancy and expanded by experience and reading to include a few centuries or a few millenia. Study of the processes of organic evolution expands the concept of time to include all the period which has biological significance and is measured in billions of years.

2. The idea of *continuity of living matter* is gained in tracing the cycle of a corn plant from seed to seed, but it takes on new significance when the continuity is established for billions of years.

3. The *expansive power of living matter* can be introduced by an account of the revegetation of Krakatoa after a volcanic eruption, but its real meaning is shown by the occupation by plants, first of the sea, then the soil, and then the surface of the land.

4. The physiologists emphasize the complexity of protoplasm as it occurs today. Only the evolutionist, who must consider not only present-day living matter but living matter of all periods, gains an adequate idea of the *complexity of biological phenomena.*

5. The essential phenomenon of organic evolution is not increase in complexity but *change,* accompanied by the *survival of a very few of the results of change.* The relevance of these ideas to almost all aspects of life, from politics to criticism of modern architecture, is clear.

Recorder's Report of Discussion on EVOLUTION AND PALEONTOLOGY

The outline of Evolution and Paleontology as presented by Dr. Petry was accepted as an adequate basis for teaching the evolution portion of a general biology course. Since the statements in the outline were challenged only in minor details, the discussions dealt mostly with extensions and implications. No two of the discussions developed along the same lines, although there were many recurring points of emphasis, and general agreement was reached in most cases. All groups in which the points were discussed agreed in principle on the following general statements:

1. The evolution concept, which can be developed in all well taught biology courses, is a good thread with which to tie ideas together in various biological sciences. Evolution, a synthesizing concept which fits into all phases of biology, is one of the fundamental contributions that biology can make to a personal philosophy.

2. The importance of time and the continuity of change in the living world are two of the most important fundamental concepts in the teaching of evolution.

3. It is important to note that even the simplest species now alive are the products of a long period of evolution and therefore not simple as compared to the earliest things.

4. The area of evolution provides excellent opportunities for the study of independent but confirming and supporting lines of evidence, such as fossils and comparative anatomy, the uranium-lead ratio and the paleontological sequence.

5. Far-fetched statements and over-dramatized presentations of evolution tend to place evolution teaching in a bad light with the public.

6. Prospective biology teachers should be given to understand that there is considerable "sales resistance" to the evolution concept, and should be prepared for it. In some localities, where there is a strong anti-evolution bias in the community, the teacher must act with unusual tact and understanding. It is his responsibility to help students through periods of difficulty associated with their ideas of a religion-evolution conflict.

7. The competent teacher can do his best job when he is free to organize his biology course as he thinks best and to use the approaches to evolution which he considers most suitable for his students and his community.

The interest in, and the response to, evolution is different at various educational levels, and the approaches that can be used depend on the maturity and experience of the teacher.

8. The teaching of evolution presents a good opportunity for pointing out that facts are facts, whether they are believed or not, and for showing how to distinguish between fact, on the one hand, and theory or belief, on the other.

9. Colleges must assume responsibility for in-service training of teachers of biology, in order to build up the breadth of training necessary for teaching such synthesizing topics as evolution. This includes graduate credit for basic courses, adjustment of prerequisites, off-campus courses, expanded summer offerings, conferences, workshops, and the like.

In the case of the next statements, there was less than complete but still substantial agreement:

1. High school students are interested primarily in man himself; therefore the best starting point for teaching evolution is to show how, to a considerable extent, man controls his own environment and directs his own evolution.

2. Students are initially more interested in objects than in ideas; therefore, whenever practical, a discussion of any phase of evolution should follow examination of some physical object, such as a fossil.

3. An important part of a teacher's responsibility is to make clear his own position concerning evolution. The competent teacher exposes his students to his own philosophy. Common sense will determine the best way to accomplish this.

Concerning the following statements there was more or less sharp disagreement, with no clear cut conclusions reached within the time allotted:

1. Biology teachers should not give final answers to social or other non-scientific questions, but should present all the facts they think concern the biology involved in the situation.

2. There is a lack of interest in laboratory work at the college level, which may result from faulty presentation or from the social evolution through which students go. A new type of laboratory experience is needed to individualize and vitalize the experience and still meet minimum requirements.

JOHN BREUKELMAN
Recorder

Morphology

C. S. CHADWICK
Head, Department of Biology
George Peabody College for Teachers

"Morphology . . . . . is one of the most interesting departments of natural history, and may almost be said to be its very soul." (Charles Darwin, *The Origin of Species.*) These two statements, (a) that morphology is interesting, and (b) that it is in large part the soul of natural history are sufficient arguments for the inclusion of a healthy dosage of morphology in the biology curriculum.

Although the history of biology has been largely the study of the form and structure of organisms, the importance of morphology seems now to reside in the fact that it provides a basis for the understanding of function, development, heredity, taxonomy, ecology and other branches of biology.

It is to be admitted readily that morphology alone is not enough, but it must be admitted also that a knowledge of morphology is prerequisite to the understanding of function. The structure and form of the organism is a framework in which and by which life functions are accomplished. Because this is true a knowledge of morphology is indispensable in any study, or in any phase or field of study, of the living organism.

The first question the inherently inquisitive student is likely to ask in regard to a thing is, "What is it?" The answer requires a knowledge of morphology. The next question will likely be, "What is it good for?" or "What does it do?" The answer to these requires a knowledge of function. Other questions will likely be, "Where did it come from?" and "How did it come to be like it is?" To answer these one has to draw upon a knowledge of embryology, evolution, genetics, ecology, etc.

If the teacher knows only morphology, or only one of the several fields of biology, he is not likely to satisfy the curiosity of the student. His training must have breadth as well as depth, and probably breadth should be the first objective.

The good general biology course at the high school or college level should provide breadth. In such a course the student would be introduced to those principles and laws which are common to all of the fields of biology. Enough morphology would be taught to provide the basis for the understanding of function. In considering protoplasm and its organizational units, the parts of the cell would have to be learned. In a sequential study of the world of living things, which would follow consideration of the cell doctrine, morphology would be taught as needed. The student would learn about cell aggregation, division of labor between somatic and germ cells, specialization of somatic cells, tissue formation, organ formation and the organ systems, without having been impressed with the fact that these are in the domain of morphology. Even the great principles of structure—metamerism, symmetry, cephalization, regional differentiation and the subdivisions of the coelom—would become evident without pointing up the fact that these are all a part of the field of morphology.

It would be in the advanced courses for a biology major that the student would gain depth. In courses in comparative anatomy, embryology, histology and cytology he would dig more deeply into the special subject of morphology. But even in these courses, function should not be excluded. There is a definite, and probably wise, trend towards functional anatomy. Instead of requiring students to learn the name, origin, insertion, action, innervation, form, position and blood supply of each individual muscle in the body, he learns muscles as functional groups. Such knowledge is more meaningful. In embryology, in addition to learning the fate of the germ layers and the successive structures which develop from them, the student would study gametogenesis, fertilization and the formation of the zygote, the mechanisms

which bring egg and sperm together, the organizers, devices for the nourishment of the developing individuals, metamorphosis, and the phenomena of hatching and parturition. To understand embryology one is forced into a study of the hormones, enzymes and genes as they relate to development. In histology and cytology the functional approach also is stressed.

Much criticism has been directed at biology in general and morphology in particular for its apparently unending terminology. It is said and rightly so, that we are not content just to have one big name for a structure, we have to have two, or three or perhaps a half dozen. We are criticized for requiring the dissection of endless, smelly, formalin-preserved specimens; for requiring the students to make too many drawings; for not having enough field-trips; for adhering too closely or not closely enough to a textbook, and so ad infinitum.

In leading our students towards a knowledge of the principles of biology we cannot exclude morphology, but we can have too much emphasis on certain phases of this area. In learning morphology we can have too much terminology or we can have too little. In laboratory practice we can require that the students make too many drawings, or too few; we can require too much dissection or we can leave some things undissected. We can have too few field trips or too many. We may put laboratory before the lecture, the lecture before the laboratory, or we may carry them along together. We may use too many audio-visual aids, or not enough. We may use a textbook much, little or not at all. We may be guilty of cook-bookery in laboratory instruction, or exhaust ourselves with verbally-given instructions. The important thing is that we do not go to any of these extremes, but rather seek a balance.

We should seek balance not only in our handling of the subject of morphology, but seek to balance morphology content with content from genetics, taxonomy, ecology, evolution, physiology and other phases of the field of biology. Only in so doing can we hope to turn out balanced, well-rounded, well-educated, biology students.

Recorder's Report of Discussion on MORPHOLOGY

Morphology, when taken in its broadest concept, concerns the study of the form and structure of living organisms. It provides a basis of interpretation and understanding of other aspects of biology, such as those of physiology, heredity, ecology, taxonomy, evolution and others.

Morphology may obtain its chief place of importance as a tool by which it forms the foundation, the superstructure or the building blocks, for the various topics of study which seem to be essential. It may also be important as a discipline itself, leading to hobby interests or further pursuits in anatomy or taxonomy.

General biology courses in the past have been largely based on structure, because of the greater amount of this type of information available. The more recent trend has been to emphasize physiology, as new discoveries have been made in that field. The general opinion of those discussing this point is that there is a definite need for balance between these areas. Thus, morphology, physiology, ecology and other phases of biology, kept in balance by an able teacher, should lead to the better understanding of basic biological principles. The real danger lies in making any one subject an end in itself, rather than an integrated whole.

Some of the principles of morphology which are important in the preparation of biology teachers include the following:

1. knowledge of organ systems in representative organisms
2. levels of organization from simple to complex
3. symmetry, metamerism and cephalization
4. regional differentiation
5. cells and the division of labor among cells
6. homology
7. the organism as an end product of heredity and environment
8. morphological evidences of evolution, physiology and taxonomy.

These principles may be projected in significant courses given as an important part of the teacher training program, and for other knowledge of biology.

Emphasis has been placed on the necessity of a *good general* biology course of at least one year duration in which there is a balance of morphology, physiology and other areas including as many of the fundamental principles of each as fits the situation. Although some participants prefer separate half-year or quarter courses in botany and zoology, the majority preferred a required general biology course during the first year to be followed by such other courses as:

1. Second Year
   a. Human Physiology
2. Third Year
   a. Nature Study, Genetics or Bacteriology

students who wish to gain a fundamental

3. Fourth Year or Graduate Level
   a. Comparative Anatomy
   b. Embryology and Histology
   c. Taxonomy
   d. Plant Morphology
   e. Ecology
   f. Entomology

The need of one or more concurrent or subsequent methods courses was recognized.

Suggestions were made that a comparable general physical science course be offered in order to give adequate background information in those physical sciences in which prospective teachers, due to lack of time, might not be able to complete year courses.

To keep in step with the current trend of teaching more science in the elementary school, there was expressed a need to examine the early work in nature study and to modify subsequent programs. The development of a practical and acceptable integrated program in science throughout elementary school, high school and college is needed.

The methods by which the principles of morphology may be taught through significant courses are many and varied. Some prefer to use such approaches to various types of subject matter as the following:

a. the functional approach
b. the problem approach
c. the question approach
d. the phylogenetic approach

Others wish to use combinations of these arising from need.

However all concurred in stressing the importance of the well-trained teacher. In addition to teacher preparation the following attributes seem important:

1. adaptability
2. desire for continued growth
3. skill in teaching techniques
4. rich experiences
5. skill in laboratory and field work
6. ability to use wisely such teaching aids such as
   a. blackboard for illustrations
   b. audio-visual aids
7. ability to be selective in requirements for dissection, drawings, student records, and reports.

The following recommendations were made:

1. that total number of clock hours of the science teacher be lightened to permit him to adequately prepare for laboratory work
2. that adequate space should be provided
3. that the teaching load of science teachers (lecture and laboratory counting equally) be determined by total number of clock hours.

RUTH DODGE
Recorder

Taxonomy

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Taxonomy, concerned with the identification and classification of organisms, has been called the oldest, the most limited, and the most inclusive of the biological sciences. The oldest because of man's early need for names; the most limited because the taxonomist has often dealt only with morphology and nomenclature; the most inclusive because proper classification depends upon the totality of our knowledge of an organism and its populations.

The word "taxonomy" is sometimes used to refer to the science that deals solely with identification and naming; the word "systematics" to refer to a broader science dealing with the problems of evolution and classification. No differentiation is made here between systematics and taxonomy.

Perhaps the best way of defining taxonomy is to describe what a taxonomist or a systematist does. He must identify, classify and name, as well as determine the factors involved in evolution. In order to identify he must study variation, not merely in a few specimens, but in a sample that reflects an acceptable approximation of the variation in a natural population. As classification necessitates an expression of the phylogenetic position, the taxonomist must utilize information on the ecology, physiology and ethology of the organism. Once the relationships of the plants or animals are determined a name must be established. Naming requires the application of an understanding of the international rules of nomenclature and a thorough knowledge of the literature of biology. To determine the pattern of evolution requires the synthesis of information from many areas of biology—particularly biogeography, biodemography, ecology, physiology and genetics.

What is the body of knowledge encompassed by taxonomy? This includes: (1) descriptions, keys, phylogenies; (2) geographic distributions, habitats, life histories; (3) variations in the attributes of natural populations; morphologic, physiologic, ecologic, demographic, genetic; (4) legalities, the international rules and their applications.

With this general approximation of taxonomy and the taxonomist as a base, we can explore the question of how such knowledge is useful to the teacher of biology.

The student beginning his study of biology is most frequently interested in specific plants or animals. What is this? What is its value? How and where does it live? This interest is used by the alert teacher to lead the student to an awareness of the general concepts and principles of biology. Both the student and teacher are frequently concerned with identification.

Perhaps the greatest value of taxonomy to student and teacher is the use of the system of classification as a frame of reference—a skeleton outline of biological knowledge. No person can know all about the plants and animals, but an understanding of the uses of the system of classification will permit vast extensions of knowledge. As classification groups organisms with similar traits together, recognition of the phylum, order, family, genus or species will provide a vast amount of information to the individual trained in taxonomy. The good teacher will frequently say "I don't know exactly what kind of an animal it is but it is a member of this genus, this family and therefore it has this origin, this physiology, this distribution, this habitat." Such knowledge permits the student to extend his knowledge of the plants and animals of one region to another.

Classification reflects the pattern of evolution, the basic theme of all biology. The type course is essentially a portrayal of the larger steps in the development of life; the principles course is an explanation of how life has evolved and survived. Either type of presentation is dependent on classification.

Taxonomy requires an application of other areas of biology and is ideal to demonstrate to the student a synthesis of biological knowl-

edge; genetics and embryology, in determining inheritance and degree of relationships; physiology, anatomy, morphology, in establishing characters of related groups; ecology, biogeography, biodemography, in determining the why of distribution; paleobiology, in interpreting the past.

Conservation education requires instruction in identification and the discussion of the attributes of populations.

If taxonomy is essential to the teacher, what aspects of the subject are important in the education of the teacher? These may be outlined as topics.

1. Collection and preparation
   Collecting techniques. Preparation of dried, fluid preserved and embedded specimens. Methods of data recording and cataloguing.
2. Identification
   Use of keys, descriptions. Evaluation of levels of identification—handbooks, monographic revisions, descriptions, types. Artificial and natural keys.
3. Classification
   Characteristics of the hierarchy of classification. Utility of classification—"filing system," relationships, phylogenies.
   Linnean system. Kinds of taxonomic characters—morphological, physiological, ecological, ethological, geographical. Diagnostic value of characters.
   Type method. Functions of the type, the hypodigm, the type locality.
4. Speciation
   Species concepts—morphological, biological. Natural populations—characteristic distributions, gene flow, isolation, intergradation, hybridization, introgression, clines.
5. Nomenclature
   History—vernacular names, scientific names; Plato, Aristotle, Ray, Linnaeus; the international commission.
   The rules of zoological and botanical nomenclature. Principles of priority, continuity, plenary powers. Legal requirements—names, descriptions, synonomy.

Unfortunately, many teachers do not gain this body of knowledge because of the traditional nature of the college curriculums in botany and zoology. The potential teacher is often unaware of: the value of the system of classification; the need for scientific names and their regulation; the attributes of the natural populations; the relation of these attributes to the formal requirements of the type system; the dangers of erroneous identifications in biology. These units of knowledge can be readily incorporated into the college courses in comparative morphology and anatomy, genetics, physiology and ecology.

Recorder's Report of Discussion on TAXONOMY

The field of systematics is of importance in the training of biology teachers in that it provides:

1. A natural framework for the extension of one's knowledge in the field of biology.
2. A logical basis for the synthesis of all biological knowledge.
3. A useful tool for naming populations of organisms and drawing conclusions as to the morphology, physiology, behavior, distribution, etc. of such populations.
4. As a discipline providing training and experience in systematizing knowledge and information.

The subject materials and experiences that should be included in the training of the biology teacher are presented in the following outline:

1. Collection and preparation.
   Collecting techniques. Preparation of dried, fluid preserved and embedded specimens. Methods of data recording and cataloguing.
2. Identification.
   Use of keys, descriptions. Evaluation of levels of identification—handbooks, monographic revisions, descriptions, types. Artificial and natural keys.
3. Classification.
   Characteristics of the hierarchy of classification. Utility of classification—"filing system," relationships, phylogenies.
   Linnean system. Kinds of taxonomic characters—morphological, physiological, ecological, geographical. Diagnostic value of characters.
   Type method. Functions of the type, the hypodigm, the type locality.

The new, dynamic science of systematics has evolved during the past few years (especially during the past decade) from the older, stereotyped Linnean taxonomy. Many, if not most, biology teachers still tend to think of taxonomy or systematics on the basis of the older concept. The more apparent differences between these two concepts are summarized in tabular form below:

	Older Taxonomy	New Systematics
Objectives	Identification and classification. (i.e., *what* is it?)	Identification and classification *PLUS* Population dynamics (i.e., *why* is it what it is?) based on disciplines such as historical geology, biogeography, biodemography, ecology, physiology, genetics, life histories, etc.
	Legal Aspects (Nomenclature)	Legal Aspects *PLUS* Biological Aspects
Attention concentrated on	Single or few preserved specimens	Living populations of plants and animals.

4. Speciation.

   Species concepts—morphological, biological. Natural populations—characteristic distributions, gene flow, isolation, intergradation, hybridization, introgression, clines.

5. Nomenclature.

   History—vernacular names, scientific names; Plato, Aristotle, Ray, Linnaeus; the international commission.

   The rules of zoological and botanical nomenclature. Principles of priority, continuity, plenary powers. Legal requirements—names, descriptions, synonomy.

Specific needs emphasized repeatedly included:

1. The need for keeping technical nomenclature at a reasonable and practical level.
2. The need for scientific names.
3. The need for explaining the "why" of systematics as well as the "how."
4. The need for teaching the prospective biology teacher basic collection and preservation techniques.
5. The need for a working knowledge of the names of common local plants and animals.
6. The need for integrating the taxonomic information outlined above in the general training of the high school biology teacher rather than presenting it as a separate unit of information.
7. The need for including historical background material throughout the biology teacher's training and experience in systematics.

ROBERT GERING
Recorder

Physiology and Health

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During the past two or three decades, biology has come into its own as an experimental science. There has been a gradual transition from the descriptive to the experimental phase in all of its subdivisions. The foundations of embryology, for example, were laid by the descriptive biologist and contributions are still being made in this area. But more recently the experimental aspects have been developed and tremendous strides have been made by investigators working in this field. In recent years evidence bearing on basic concepts in taxonomy, phylogeny, evolution, etc. has been obtained from genetical, biochemical and serological studies.

To understand and appreciate the full implications of 20th Century biology, the teacher and the student must be fully aware of the impact of experimental biology. This has no sharp boundaries for it reaches out toward chemistry, through biochemistry; toward physics, through biophysics; and toward mathematics, through quantitative biology.

Physiology is the study of the functioning of organisms and their component parts. It stands at the crossroads between descriptive biology on the one hand, and chemistry, physics and mathematics on the other. Not all of experimental biology is physiology, but very frequently the techniques which were used first by the physiologist, are now being applied to other areas of biology. Actually, it should not concern us whether we say the man who is studying the distribution of certain enzymes in a developing embryo is an embryologist, a physiologist or a biochemist. The important thing to us as teachers and students of biology is to be in a position to appreciate the general biological significance of such data even if we do not understand the details.

Physiology is a broad field with many facets. Roughly we can recognize three major subdivisions: (1) organ system physiology; (2) general physiology; and (3) comparative physiology. Let us briefly consider some of the most obvious implications of an appreciation of each of these areas.

Organ system physiology. It is difficult to select an appropriate term to describe this area. Perhaps *Mammalian Physiology* would be better, but rather than labor the problem of what to call it, let us briefly describe what we mean. This is the kind of physiology with which all of us are familiar. It involves a study of how the various organ systems function, as for example: what happens to food when it passes down the alimentary canal; how does the heart function and what changes occur in the blood as it circulates; how do we breathe; what mechanisms coordinate these systems into a whole; and so on. Most high school and college biology texts have at least some discussion of this aspect of physiology, and with the recent emphasis on human biology, further impetus has been given to the study of human physiology.

In the broadest meanings of the terms, medicine is applied physiology. A doctor must first understand the normal functioning of the body before he can determine the extent and possible causes of abnormal functioning (diseases). The standard "tools" of every doctor—the thermometer, the stethoscope, the sphygmomanometer—are instruments for testing the basic functioning of the body. A knowledge of human physiology, then, is a necessary requisite for evaluating and exercising good health practices. With so many articles in the press concerning health and medicine, a person must understand at least the basic principles of human physiology in order to read intelligently. Furthermore, since physiology is an experimental science, an acquaintance with its methods should contribute to an appreciation of scientific methods. This is necessary in order to evaluate the many news releases pertaining to health and medicine.

General Physiology—The two remaining broad areas of physiology are, for the most part, completely overlooked in the training of most teachers and students of biology. This

results, in part, from the fact that a broad background in physics, chemistry and mathematics is required, since general and cellular physiology are concerned with the physical and chemical aspects of functioning. However, a knowledge of some of the basic principles, and the implications thereof, can be obtained without a complete appreciation of all the details.

To illustrate, let us consider the carbon cycle. Here is a topic about which all biologists talk, but of which very few have any real knowledge. We all know that organic compounds containing carbon are originally synthesized by green plants in the process called photosynthesis, and are subsequently broken down into carbon dioxide by both plants and animals in the process called respiration. In addition, we all know that the breakdown occurs in a stepwise fashion, that enzymes are necessary, and that energy is released during the process. But how many of us are familiar with the details of glycolysis, the Krebs Cycle, the terminal oxidative steps, the role of phosphorylations, etc.? The important thing is not to memorize all of the biochemical changes involved in respiration, but rather to have some feeling for the role enzymes play, the formation of molecules with high energy bonds, the overall complexity of the processes, etc.

We all teach a great deal about vitamins, but how many of us actually have any idea of how vitamins function in the body? The biochemist in his studies of respiration has discovered how the B-vitamins function in enzyme systems. The details of this story are not as important to the student and teacher of biology as is the fact that some vitamins, at least, do function in this manner. Many other similar examples could be given, but this should serve to illustrate the fundamental importance to all biologists of general physiology.

Comparative Physiology—The emphasis of this area of physiology is placed on a comparison of the functioning of a particular type of cell, tissue, organ, or organ system in representatives of many phyla of animals. Evidence from this field is of increasing importance in indicating phylogenetic relationships. For example, the distribution of certain organic phosphates in the echinoderms and protochordates supplies data of interest in a consideration of the origin of the vertebrates. Studies such as those of the photochemical reactions in the rods and cones of various vertebrates make a real contribution to general problems of the origin of vertebrates.

In conclusion, then, the training of a teacher and a student in modern biology should include a great deal more emphasis on experimental biology than many of us have had. Not only should we be aware of the basic facts concerning the functioning of an intact organism such has man, himself, but also we should be able to appreciate some of the aspects of function at the cellular level and the implications of a comparative study of functioning.

Recorder's Report of Discussion on PHYSIOLOGY AND HEALTH

Biology as a science is becoming increasingly analytical, experimental, physiological and integrative. Certain important descriptive contributions will continue to be made, but more and more advances in the field are analytical. All teaching of biology at every educational level must reflect this trend. Otherwise, teachers will fail to prepare their students to understand and apply modern biology.

Among teachers' needs, if they are to do this job properly, is a stronger training in physiology than very many have hitherto received. Life is functional; physiology is basic to an understanding of biological systems as dynamic systems. Physiology also provides opportunity for giving students other types of needed experiences, including illustrations of a quantitative aspect of biology and the opportunity to learn scientific methods through activities. Since teachers, by and large, teach from the background of their own learning, they can give their students essential and accurate information, knowledge and experiences in this area only if they are themselves adequately trained in physiology.

Desirable training in physiology should include three broad areas with some such list of subtopics as:

1. General physiology
   a. energy relationships: chemo- and photosynthesis and cell metabolism
   b. diffusion and permeability, including water and salt balance
   c. electrical and irritability phenomena

d. mechanisms of growth and development
2. Mammalian organ-system physiology
   a. functions of basic organ systems integrated with embryology and morphology
   b. health training derived as applied human physiology plus human ecology (including social and psychological factors)
3. Comparative physiology
   a. comparisons of basic life functions—nutrition, internal transport, motion and locomotion, etc.—among micro-organisms, plants, and animals.

Many teachers of high school and college general biology are inadequately prepared in general physiology. Factors responsible for this deficiency include: the new and rapidly changing character of the field, unawareness of its significance on the part of curriculum-planners and administrators, and the need for a sound background in the physical and biological sciences as prerequisite to the study of general physiology. The principles of general physiology are basic in understanding every aspect of the lives of organisms and can be taught effectively in general biology. The teacher must be prepared to distill the essentials and incorporate them in general courses.

Some of the general physiology required by the prospective teacher should appear in the college course in general biology. Its inclusion is justified even if this necessitates the compression of some traditional topics. For example, time can be saved by integrating physiology and morphology in instruction. Since students learn some human physiology from elementary school on, parts of this can be condensed. At this level, the needed information in physics and chemistry can easily and quickly be presented where needed to interpret general physiology. So deficient knowledge in the physical sciences is no barrier. Indeed, prospective teachers should see how this can be done, since they will have to use similar methods in their own teaching.

Ideally, the curriculum for the teacher of biology should include chemistry through organic, basic college physics, some mathematics and one or more advanced courses in physiology. If time permits only one such course, it should include a proportionate amount of all three subfields. It should certainly not be restricted to human physiology as is too often the current practice. Human physiology is clearly essential. It is satisfying to find that colleges now generally provide good courses in this subject for the teacher and that such instruction will continue. However, where time does not permit separate general, comparative and human physiology courses, the combined physiology course is preferred to one in human physiology. The organ system material can often be somewhat condensed to permit inclusion of general aspects. Extensive preparation in comparative physiology is least essential, but some should appear for it will enable the teacher to interpret other areas of biology—development, ecology, phylogeny, evolutionary dynamics—on a physiological basis. Much of comparative physiology can be woven into other biology courses presented to the teachers.

Wherever physiology appears in courses for teachers, instructors should make special efforts to employ simple experiments and other teaching aids, often making use of readily available materials, experiments and projects that teachers can carry over into their own practice in inadequately equipped classrooms. Experience with more elaborate equipment and methods is valuable also. The teacher will then know how to use such equipment if it is available, or at least can explain its use if it is unavailable. The broadly trained teacher is best able to stimulate, counsel and guide interested and talented students who may embark on special work or be led into biological careers. Teachers in service also urgently need handbooks of suitable experiments and aids in physiology, and other newer areas in biology. If biologists themselves do not meet this demand, those not qualified will attempt it to the detriment of sound biology teaching.

Finally, it is contended that the biology teacher is the person best qualified to give health instruction. Based on a sound background, in which human physiology and ecology are of special importance, the good teacher can be expected to adapt and orient his knowledge to the needs of the students in such a course. This should provide a solution for the inadequate health instruction which is so widely prevalent today.

RICHARD PAULSON
Recorder

Ecology and Conservation

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The basic justification for biology in a general education curriculum is ecological. Only on the basis that it can contribute effectively to man's adjustment to his environment has biology been able to reoccupy a respectable position in the public schools, after the virtually complete displacement of earlier descriptive botany and zoology a generation ago. From this point of view certain interrelated assumptions are made which have implications in teacher training: (1) that an awareness of landscape, biological as well as physical, is a desirable general education objective; (2) that it is appropriate for public concern with the population and resource outlook to continue to increase; (3) that an ecological point of view is important in our culture, which has now left behind the pioneer exploitative phase with its "ever-expanding economy"; and (4) that it is essential for man to see himself as part of the community of living things whose control he has assumed.

These implied objectives may be approached in three general ways: (1) through the underlying philosophy and pervading point of view in the training program to which prospective teachers are exposed; (2) through breadth of training of prospective teachers; and (3) through specific experiences which prospective teachers may pass on, in some degree, to their own students. All three of these approaches are important. Each is most effective in combination with the others.

Perhaps the most fundamental contribution of ecology to education is its integrative function. With its focus of attention on the relationships between living organisms and their physical environment, it bridges the artificial but traditional gap between physical and biological sciences. When it is projected through value judgments into a conservative program, it enters the area of social science, breaching an even stronger traditional barrier, and tapping the effective motivation of enlightened self-interest.

Only the most hide-bound traditionalist would today deny the usefulness of an ecological point of view as a vantage point from which such integration of the physical and biological might be accomplished, and as a springboard from which conservation of renewable resources might be logically approached. But without something to integrate, without a broad base on which to erect the conservation application of fundamental ecology, the whole program collapses for want of substance. The problem is a familiar one in teacher-training programs—"too much time learning how to teach, too little time learning what to teach." The following statement, quoted from a recent popular botany textbook, is pertinent:

> "The science of ecology is one of the most expansive and intricate fields of biology: it involves the consideration of exceedingly complex factors and relationships, and its searching and discriminating study requires extensive field experience and a formidable background in taxonomy, plant physiology, chemistry, physics, geography, geology, mathematics (with particular emphasis upon statistical procedures), meteorology, and soil science."

I am glad to be able to quote this statement from authors who are not themselves ecologists, for it illustrates the increasing recognition in modern textbooks of the integrative role of ecology and the importance of breadth of training in related fields for proper exploitation of this very useful central theme. The modern texts in botany and biology have led the move in this direction, and the revisions of older texts have often followed suit. Evolution and the history of life on the earth were the culminating generalizations of traditional courses with morphological emphasis. But with the swing toward more practical courses, easier to justify in general education and more useful to the applied fields, physiology and its ecological applications came to

occupy more and more space, and tended to crowd comparative morphology into a more compact survey. Evolution and paleontology came to be treated more as applications of genetics and ecology, which were needed to set the stage for an understanding of present-day biogeography, human land use, and its projection into the future which we call conservation, and ecology became the culminating theme of the final chapters, with economic biology and conservation as its ultimate applications.

It is doubtful if anyone would argue against the case for breadth of training, but in actual competition with the "vested interests" in the curriculum, we may as well admit that a good many of the ideal courses will be left out. It is suggested that the practical answers to this problem may lie in several directions: (1) more effective guidance, based on greater familiarity of the advisers with the courses available, and willingness to assign priority ratings to the courses available in a particular institution with respect to the individual student's background and needs; (2) discouragement of premature specialization in a phase of biology at undergraduate level, at the expense of breadth, perhaps requiring in some institutions a special curriculum accepting a higher than usual proportion of freshman and sophomore subjects; (3) planning of the more general courses, such as ecology and geography, which have some license to cross interdisciplinary boundaries, so as to provide for filling of the usual background gaps; considerable attention to meteorology and soil science is thus given in many ecology courses; (4) periodic reexamination of the curriculum with special attention to competing fixed requirements, in the light of actual teacher experience in the field.

Most of our educational philosophy and our basic techniques as teachers stem from our earlier experiences as students. The training program owes prospective teachers not only perspective and background from which judgments may be made and questions answered, but also specific experiences which may be shared later with their own students. Field work is especially important in this connection—familiarization with the conspicuous biological elements on the landscape, recognition of habitat restriction of organisms, recognition of communities and something of their organization and dynamics, observation of light, moisture, and soil differences in contrasting habitats. Certainly no teacher who has been denied such preparation can be reasonably expected to conduct an effective field program, or even to wish to do so.

In this connection an excellent remedial contribution has been made by the conservation camps and workshops which have sprung up in the last few years under various sponsors. Although almost universally handicapped by the great differences in level of preparation among their too few participants, and sometimes satisfied with what appears to be a superficial level, they have succeeded in introducing many teachers to field experiences and sources of information and assistance, generating strong enthusiasm and not infrequent interest in further basic work.

It is evident that conservation will be taught. The public is concerned with population and resource problems and this concern will inevitably increase with the fore and aft motivation of idealism and fear. If conservation is not taught by biologists, from an ecological point of view, it will be taught, or manipulated, by others with far less adequate preparation. The door is open; the pathway is already clearly blazed; opportunity and responsibility for biology lie ahead!

Recorder's Report of Discussion on **ECOLOGY AND CONSERVATION**

At this point in the "time dimension" there is agreement that the ecological approach to biology teaching is the general education approach. On this matter, the groups accept Dr. Shanks' statement that "The basic justification for biology in a general education curriculum is ecological," and that, "Perhaps the most fundamental contribution of ecology to education is its integrative function."

There is also agreement that the acceptance of the ecology-conservation point of view involves:

1. an undergirding of much fundamental knowledge
2. first hand experience, including field observations and experimentations

3. the individual differences and needs of organisms, including man
4. the ability to reserve judgments and to weigh values
5. the making of value judgments.

In committing themselves to the ecology-conservation point of view, and to the point of view that the biology teacher is the person to handle this work, the next logical question is: *What training does a teacher of biology need for successful operation in an ecological setting?* Among the answers to this question are:

1. Experience and training in the various areas of both the biological and physical sciences. In this training it is better to sacrifice depth rather than breadth. This training should include enough fundamental information to set the stage for intelligent ecological decisions.

2. Acquaintance with the immediate environment.

3. Training in the making of value judgments. The tendency of scientists is to delay the making of value judgments. In spite of this, they must keep in mind that they have the responsibility to give their students a "decision basis" for the solution of our ecological and conservation problems.

As to how fundamental knowledge can best be gained, many have the feeling that it should come through an ecological situation—actual first hand experiences in natural habitats; some feel that this basic information might best be gained through other approaches. All are in agreement that ecology can be used effectively as a "binding material" for a meaningful study of the often divergent areas of the biological and physical sciences.

What means can be used to extend the education of teachers now in service? It was admitted that teachers *can* be educated. Much can be done on their own by keeping up with the research projects being carried on by individuals, corporations, as well as state and federal agencies. The biology teacher stands in a strategic position to weld the contributions of these agencies into meaningful situations. In addition to regular graduate work in the subject matter areas, workshops are considered valuable means for the improvement of biology teaching. The reading of somewhat simple lay books, with the ecology-conservation slant, is advocated. In the training of in-service teachers two things are felt to be of great significance: (1) the inclusion of field work and (2) the omission of highly technical terminology.

After he has the essential training, how can a teacher include ecology in a crowded curriculum? First of all they need to evaluate the present biology program. Perhaps with a fresh point of view and more efficient use of time, the fundamental materials, now found in the texts, can become more meaningful in an ecological atmosphere.

Early natural history courses were concerned chiefly with the "Environment" and "What the Organism Does," with little concern for the "Internal Conditions and Processes." Ecology involves a complete picture.

A competent biology teacher, with broad training in fundamentals, will be challenged by the many opportunities to teach physiology offered in presenting the process of photosynthesis to his class. Accepting this challenge will lead to a more vitalized course, with the fundamental biological principles taking on meaning even for the average student.

What should the results be? Biology taught in an ecological setting should cause the student to feel at home in his environment, with all this involved. He should also have a better basis for value judgments with all their social implications.

MALVINA TRUSSEL
Recorder

Summary of the Scientists' Contributions

HOWARD M. PHILLIPS
Dean of the Graduate School
Emory University

One of the major objectives, identified for the participants of the Southeastern Work Conference on the Teaching of Biology, involved a study of the contributions of the various biological sciences which could be utilized in developing a set of basic principles and experiences considered essential for biology teachers and pupils. In order to emphasize the recognized needs, particularly from the standpoint of modern concepts and theories, six scientists representing six areas of biology: (1) heredity and development, (2) evolution and paleontology, (3) morphology, (4) taxonomy, (5) physiology and health, (6) ecology and conservation—were asked to prepare papers and lead discussions pertinent to particular subjects and their relationships. The group of participants was divided appropriately into six "vertical" sub-groups of approximately equal, varied representation.

Early in the Conference, it became increasingly clear that the crux of the major objectives resided in the teacher, the pupil, and the relationship between the two. Contributions, therefore, were based on an idealistic-realistic approach by the scientists. The potentialities of the well-educated individual were especially emphasized.

As an aid to the teacher's development of proper attitudes and concepts relative to biology, it was emphasized that efforts must be made to capture the interests of a youth at an early stage of his development. One of the most complex processes known to man is the education of the growing and maturing human being. The acquisition of additional knowledge and advancements in science certainly have not decreased the complexity. The subtle, often intangible, human experiences which result in the creation of ideas, ideals, and aspirations have to be considered of vital importance, since their multiple effects are of far reaching quality. The necessity for intellectual discipline and exact performance to supplement the stimulation and enthusiasm engendered in the educational process of the biology teacher was recognized as one of the important contributions of the scientist.

Biology is a body of knowledge of a highly organized nature. It can not be resolved into a single subject or course. The field has been characterized by dividing, subdividing and "splintering" to the extent that it has lent itself to over-specialization and "discontinuous" classification. The problems associated with this particular science have become further complicated, according to some viewpoints, as a result of its becoming increasingly analytical, experimental, and physiological. The viewpoint has been expressed that, "Today it is manifestly impossible for any single individual to become competent in more than one—or at the most a few—fields of knowledge. In our modern social and economic structure, progress and productive activity depend upon division of labor in intellectual as well as the other skills." This statement has been presented as a warning to some of the conferees who insisted upon "adequate knowledge in all areas." The warning does not imply the lack of a need for synthesis and integration in all educational programs. Actually, there have been some encouraging developments in this direction at this conference. It was the definite belief of the group that "general education" could be accomplished at the high school and college levels, provided the requirements were not too intensive in any one area. On the other hand, we can not expect the teacher to acquire all of the skills, techniques, and accumulated knowledge in all areas of learning.

One of the most interesting and fascinating aspects of the reports and discussions of the scientists was the way in which a group of specialists quickly became generalists. There were some interesting arguments proposed to provide for the use of any one of the areas as *the one* around which an integrated course or curriculum could be developed. The effective manner in which these ideas were presented has probably resulted in 6-way, split personalities among the conferees. Paradoxical situations were created, however, when each scientist, in an attempt to be fair, insisted that the individual subject could be integrated without specific reference to the area by name. Additional complications arose as a

result of a certain amount of pressure from the scientist to treat each area as a recognizable, distinct discipline.

In the area of genetics and development, mitotic and meiotic pheonomena, life cycles, internal and external environments received special attention. The extent to which these should be studied was emphasized in each case. Minimal knowledge of the following was recommended for teachers: (1) Mendel's basic laws, (2) polyhybrids, (3) sex inheritance, (4) linear order of the genes, including linkage and crossing over, (5) mutation, (6) biochemical genetics, (7) polygenes and the multiple effects of single genes, (8) radiation effects on the hereditary mechanism, (9) population genetics, (10) human genetics and eugenics.

The study of evolution and paleontology emphasized the importance of time and the continuity of change in the living world as two of the most important fundamental concepts in the teaching of evolution. It was also pointed out that even the most simple species now alive are the products of a long period of evolution, and therefore are not as simple as their original or primitive ancestors.

The teacher's position in certain localities where there is a strong anti-evolution bias in the community is a difficult one. He should always recognize, however, his responsibility to help and encourage students through periods of difficulty associated with their ideas of a religion-evolution conflict. The teacher should always make clear to the students his own position concerning evolution.

Evolution and paleontology were presented on the basis of two fundamental assumptions of the scientist: (1) that the universe as a whole displays order, and (2) that man has reached a sufficiently advanced stage in his own evolution to enable him to examine, interpret, and understand that order. The fundamental concepts of organic evolution were identified and discussed. The concepts and information contributed by paleontology were recognized and evaluated.

The generalized view was held "that from a single original form of life, or from a relatively few original forms, of very simple organization, other forms of greater complexity have, in some manner, been developed; that from these forms still others, mostly of greater complexity, but sometimes of simpler organization, have been developed in a similar manner; that this process has continued at varying rates but without interruption from the time of the beginning of life on the earth to the present time, and is now going on; and that all known organisms, both extinct and living, both plant and animal, have arisen in the same way."

Morphology's primary place of importance was assigned to its role "as a tool by which it forms the foundation, the superstructure or the protoplasmic bricks" for the various topics of study which seem to be essential in biology. For many years morphology, especially descriptive morphology, played a very prominent role in biology. Emphasis during discussion sessions was placed on the need for (1) a better balance between morphology and the other areas of study, and (2) inclusion of the more modern approaches and methods in the teaching of morphology.

The following principles and concepts were considered necessary for the teacher: (1) knowledge or organ systems in representative organisms, (2) levels or organization from the simple to the complex, (3) symmetry, metamerism, and cephalization, (4) regional differentiation, (5) cells and the division of labor among cells, (6) homology, (7) the organism as an end product of heredity and environment, (8) morphological evidences of evolution, physiology, and taxonomy.

Taxonomy was described as "the new, dynamic science of systematics which has evolved during the past few years from the older, stereotyped Linnean taxonomy." The field of taxonomy should provide: (1) a natural framework for the extension of one's knowledge in the field of biology, (2) a logical basis for the synthesis of all biological knowledge, (3) a useful tool for naming populations of organisms and drawing, conclusions as to morphology, physiology, behavior, distribution, etc. of such populations, (4) a discipline providing training and experience in systematizing knowledge and information. The subject materials and experiences should include: (1) collection and preparation, (2) identification, (3), classification, (4) speciation, (5) nomenclature.

Since life is functional, physiology was presented as basic to an understanding of biological systems as *dynamic systems.* Desirable training in physiology should include at least

three broad areas: (1) general physiology, including energy relationships; photosynthesis and cell matabolism; diffusion and permeability; electrical and irritability phenomena; mechanisms of growth and development, (2) mammalian organ-system physiology, including functions of basic organ systems integrated with embrology and morphology; health training as applied to human physiology plus human ecology, (3) comparative physiology, including comparisons of basic life functions; nutrition; internal transport; motion and locomotion.

In addition to these basic areas, it was considered necessary for the teacher's education to include chemistry through organic, basic college physics, some mathematics, and one or more advanced courses in physiology. At least one course in physiology should be taken that would include a proportionate amount of all three sub-fields mentioned above. An inclusion of an understanding of human physiology was considered as "clearly essential." It was generally agreed that instruction in health should be given by a biology teacher. It was concluded that the area of health education presented a real problem; it is an area in which the need for great improvement is apparent.

The importance of ecology as an integrative science was particularly stressed, and the suggestion was generally adopted by the conferees. An acceptance of the ecology-conservation point of view involved: (1) an undergirding of much fundamental knowledge, (2) first hand experiences, including field observations and experimentation, (3) the individual difference and needs of organisms, including man, (4) the ability to reserve judgment and weigh values, (5) the making of value judgments.

In order to operate successfully in an "ecological setting," the teacher would need: (1) experience and training in the various areas of both the biological and physical sciences, (2) acquaintance with immediate environment, (3) training in the making of value judgments—an area of cerebral activity usually ignored or deferred by most scientists.

In the training of in-service teachers, two things are thought to be of great significance: (1) the inclusion of field work, (2) the omission of highly technical terminology.

In general, the conferees were satisfied with the selection and presentation of the six areas. There were several threads of thought which characterized the discussions in all of the committees. Particularly emphasized were: (1) colleges and universities must assume responsibility for in-service training of teachers of biology in order to build up the breadth of training necessary for teaching or synthesizing topics; (2) special courses in biology and science workshops, requiring no prerequisites and which would receive graduate credit were recommended; (3) the need for integration and synthesis in all courses and programs in biology; (4) at the present, there is a lack of interest in laboratory work, especially at the beginning college level. There is a need, therefore, for providing an entirely new, and perhaps unique type of laboratory experience; (5) to impress on all teachers the fact that science is not final nor are so-called authorities final; (6) the need to know why as well as how; (7) an admission that the teacher can be taught; (8) the assumption that the scientific method is not a "sacred cow."

Many contributions have been derived from Section I. Perhaps the greatest possible contribution would come as a result of the adoption of the program of biology discussed and approved by the conferees. With only a few exceptions, however, programs and courses of this type do not exist. Admittedly, courses in general biology, general botany, and general zoology, could utilize and encompass the ideas, ideals and concepts, and principles suggested, but the simple question may be asked—Do they? Not if we insist that the principles and concepts, and their integration, be applied exclusively either to plants or to animals.

What ever the scientist may offer as contributions to the education of the teacher, two ingredients, quality and high standards, should become inseparable parts. Quoting from a recent bulletin of the University of Wisconsin: "Universities have a double task: educating responsible citizens and providing the means by which man can continue to lift himself from ignorance. Someone has said that the only way a student can acquire the ability to think is to be associated with a teacher who thinks."

Group meetings at the Conference.

PART II Identification and Selection of Problems in Biology Teaching

Section A

The Public School Program

A summary prepared from requested papers submitted to the Southeastern Work Conference on Biology Teaching.

Individual papers were written by:

ANNIE SUE BROWN, *Science Coordinator*, Atlanta City Schools, Atlanta, Georgia

MRS. ALDINA S. GATES, Baton Rouge High School, Baton Rouge, Louisiana

C. R. HAGER, *Superintendent Jessamine County*, Nicholasville, Kentucky.

MARY-RUBY JOHNS, *Biology Teacher*, Hillsborough Senior High School, Tampa, Florida

B. L. RICKS, *Science Teacher*, West Point High School, West Point, Mississippi

The summarizing of the information presented by the five papers concerning some of the basic problems that must be faced by the biology teacher in the total school program has shown the need to analyze the position of the teacher.

In spite of certain limiting elements, the formulating of procedures to help the student develop a oneness with his environment as a citizen depends upon the personality of the teacher. The teacher serves in a dual role. He is both the product of the university and an important contributing factor in the continuous chain into the universities. It is evident that people in the higher levels of education must not only manufacture a better teacher product but must help the end product, the high school teacher, to meet the complexities of his problem.

1. *Availability of teachers with adequate training in biology*

The lack of teachers with adequate training in biology is not necessarily a problem concerned with certification but rather with qualification. In some cases inadequately prepared teachers are teaching biology. In other cases well qualified biology teachers are not teaching biology because of local situations—yet no plan has been made to utilize such teachers. There is a definite need to handle the material at hand before encouraging too large a number of biology majors with no demand for biology teachers.

2. *Relationship of biology to the rest of program*

The importance of biology is generally recognized in planning the school program—yet it has been isolated. In most schools adequate plans have not been made for its integration in the total school program. The individual teacher is generally concerned with integration of the science program but not the total school program.

3. *Adequacy of coverage of important content areas in biology*

Coverage of content areas in biology has been developed either by following a well selected text or by cooperation of teachers and consultants working out definite units thought to be essential in any biology course. Some of the areas to be covered have been determined in summer workshops under the guidance of trained personnel.

4. *Adequacy of texts and other materials*

Most teachers depend upon their resourcefulness to supplement a biology text with good material from reliable sources. In some instances the classroom teacher has been asked to assist in the selection of a new biology text. In states where the texts are issued free to the student, new texts do not quickly substitute for the "out-of-date" book. Most teachers feel textbook material, in general, is adequate.

5. *Adequacy of laboratory, equipment and outdoor study areas*

Amount of equipment in a school laboratory does not create a problem for the teacher well trained in laboratory techniques. Very often the lack of space caused by the small size of room or by the use of the room by a physical science teacher does not cause a serious problem. Students are encouraged to assist in the development of a good laboratory.

Quite frequently time is a limiting element in preventing use of outdoor study areas. Many schools divide the school day into fifty or sixty minute periods.

Extended field trips during the school day are very difficult to include in the biology planning. Securing transportation, in most instances, is not possible. Other departments, emphasized by public interest, in many cases are allotted most of the free school time available for extended field trips.

6. *Effectiveness of biology program in meeting the needs and interests of students.*

The needs of the student are not always easy to determine. Needs are sometimes defined as being a matter of selecting a vocation or the choosing of a college to continue working toward this end. Some teachers feel that the student should be guided in learning how to meet his social responsibilities.

There exists a dearth of understanding between educators at the secondary and college levels as to what the needs are. The teacher often finds himself in the position of either fitting a student to meet certain specialized college requirements, or of fitting him generally to meet life's responsibilities.

7. *Effectiveness of testing and evaluation procedures*

Several types of testing and evaluations appear to be used by the teacher in the secondary school. Some tests are very formal being given at the completion of laboratory work, units and one six weeks' periods. Other teachers are not guided in the type of test used, but are "left to their own devices." There is some doubt in the minds of many teachers about the effectiveness of present testing and evaluation methods.

8. *Assistance, leadership and supervision by administrators*

Administrators do not provide enough leadership in the field of science, but this is a budgetary problem and not due to lack of interest. School funds do allow the employing of a limited number of supervisors. Administrators and supervisors are as helpful as time and number permit. Where there is no certification for supervisors there is little or no attempt to help the teacher with his problems.

Summary by MARY-RUBY JOHNS

Section B

Special Problems in the Training of Biology Teachers

A summary prepared from requested papers submitted to the Southeastern Work Conference on Biology Teaching.

Individual papers were written by:

HUBERT B. CROUCH, *Professor of Biology*, Tennessee State University, Nashville, Tennessee

RAY DERRICK, *Head, Biology Department*, Appalachian State Teachers College, Boone, North Carolina

W. G. ERWIN, *Biology Department*, Northwestern State College, Natchitoches, Louisiana

WILLIAM OWSLEY, *Professor of Biology*, Morehead State College, Morehead, Kentucky

W. W. WYATT, *Associate Professor of Education*, University of Tennessee, Knoxville, Tennessee

Adequate coverage of essential biological information in teacher preparation is a necessity. In a recent (1952) survey, the Federal Office of Education found that only 59% of the high school biology teachers have a college major in the biological sciences. More adequate training of elementary school teachers in the life sciences is also needed. Limiting factors in attaining adequate coverage of essential information are: (1) the typical and traditional course offerings, (2) the increasing demands for more general ("liberal arts") education in the undergraduates' total program, (3) the minimum certification requirements—which encourage superficiality in biology teacher education, (4) the tendency to employ and assign teachers to areas in which they are not qualified and, (5) the paucity of upper division biology courses in summer school programs.

The training of biology teachers generally can be covered adequately in schools which permit a single major. In many colleges, however, teacher preparation is only one of the school's several functions. Factors such as staff load, laboratory facilities and budgetary considerations limit the scheduling of courses which have particular value to prospective biology teachers.

Overspecialization is a problem. More general training in both zoology and botany is needed. Rapid increase of biological knowledge has made the selection of teaching materials increasingly difficult. Criteria are needed for the selection of materials for teaching essential biological knowledge.

Suggested programs for educating biology teachers are numerous. There is a growing appreciation for the importance of student teaching, with supervision and conferences, under the direction of an outstanding teacher. The fact that many academic teachers have had little or no professional educational training becomes doubly important because most high school teachers imitate their college teachers regardless of other training.

Limiting factors in making available the most desirable kinds of student teaching experiences include: (1) insufficient time spent in student teaching, (2) too many student teachers per supervisor, (3) inadequately prepared supervising teachers and, (4) inadequate library, laboratory and classroom facilities.

Other outstanding needs include: (1) biology teachers trained to stimulate interest in their students for the field of biology, (2) more graduate courses designed specifically for improving the teaching competence of secondary school biology teachers, (3) training prospective high school biology teachers to improvise as well as to make maximum use of free and inexpensive teaching aids and, (4) to encourage—rather than discourage—superior students to become teachers.

It is generally conceded that about one-half of the work for the baccalaureate degree should be devoted to science courses. The problems concerned with certification of biology teachers are numerous. Several states issue certificates in "science" but not in biology. The possibility of certification of teachers on some basis other than traditional course hours should be considered. It is probably more important to work toward enforcement of existing certification requirements than to increase minimal standards at present.

Most larger colleges are adequately equipped for the training of high school biology teachers, but many smaller schools are not. Many teachers are not adequatley trained to train biology teachers. One of the most urgent needs in the training of biology teachers is the improvement of teaching and supervisory personnel at the college and university level.

Cooperative action between representatives of education and science departments is imperative. Although a gulf exists between the "education people" and the "academicians," and the problem becomes more acute in multiple-purpose institutions, there is a growing understanding and concern among members of academic departments relative to betterment of science education. Every possible effort should be made to encourage and accelerate this encouraging trend.

Summary by ROBERT GERING

Section C

State Program in Biology

A summary prepared from requested papers submitted to the Southeastern Work Conference on Biology Teaching.

Individual papers were written by:

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LOUISE COMBS, *Director, Division of Teacher Education and Certification*, Kentucky State Department of Education

A. B. COOPER, *Director, Certification and Teacher Training*, Tennessee State Department of Education

HENRY A. SHANNON, *Adviser in Science and Mathematics*, North Carolina Department of Public Instruction

G. W. SMITH, *Supervisor of Instruction*, Alabama Department of Education

PERCY H. WARREN, *Dean, Professor of Biology*, Madison College, Harrisburg, Virginia

The following summary of the problems relating to a State Program in Biology has to be limited. It does not reflect the picture in all the Southeastern states because only six states were covered. It does not necessarily reflect an agreement by representatives from all six states on any one of the four topics covered, because some papers were lengthy in explanation on one question and entirely omitted others. An attempt, however, has been made to indicate points upon which there

seemed to be some general agreement and to emphasize these in the summary.

While Institutions of Higher Learning have adequate personnel and facilities for training biology teachers, courses are geared to the specialist and do not meet the needs of future teachers. It is felt that more courses are not the answer. Instead the content and instructional procedure of college biology teaching should be modified to deal with the fact that few secondary school biology teachers are teaching only biology, but usually have one or more classes in general science.

Out of 884 North Carolina teachers (white and Negro) certified in 1952-53 to teach science subjects, 275 were teaching science alone, 164 were teaching mathematics and science, 111 home economics and science, 42 physical education and science, 87 social studies and science, and 205 were teaching biology, physics, chemistry and other combinations.

In the Georgia secondary schools approximately 700 classes in biology are offered, but about 600 of them are being taught by teachers who are also teaching other subjects.

In Virginia biology teachers usually teach other subjects in addition to biology. One study revealed that 34% of the science teachers taught only one class in science and that an additional 21% taught only 2 classes. Since the typical load for a Virginia high school teacher is 5 classes per day, the data indicates that these teachers are devoting the majority of their time to activities outside the field of science. Since a situation exists in which few high school biology teachers can teach only biology, in many cases they are teaching with a minimum certification requirement of 12 semester hours in biology.

In 1947-48, of all science teachers in Georgia secondary schools, about 4% had no college science, 40% had 18 semester hours or less of college science, and 57% had more than 18 semester hours. In biology, 12% had no college biology, 68% had 18 semester hours or less, and only 20% had more than 18 semester hours in college biology.

In addition, the number of prospective teachers preparing to teach biology is apparently declining. In Georgia from the ten colleges for whites having State approved programs, 61 eligible science teachers were graduated in 1952, 51 in 1953 and only 43 in 1954. From the Negro colleges, 11 eligible science teachers were graduated in 1952, 33 in 1953 and 40 in 1954. The grand total for all the Georgia colleges preparing science teachers shows 77 graduated in 1952, 84 in 1953 and 83 in 1954. In proportion to the secondary school enrollment, this represents a considerable decline.

Many college graduates prepared specifically to teach biology do not enter the teaching profession, resulting in a further shortage of qualified biology teachers. However, this factor is sometimes not apparent if one considers only statistical studies of supply and demand.

For instance, in a North Carolina survey made for the year 1953-54, 295 science teachers (white and Negro) were available to meet a demand for 177 teachers. In the field of biology, the demand for 6 white teachers was met by a supply of only 1, whereas with no demand for Negro teachers there was a supply of 34. Of the total, 175 white teachers were available to fill a demand for 133, and 120 Negro teachers were available to fill the demand for 40 teachers.

No exact figures are available as to the per cent of the 175 certificated teachers who were willing to and did enter the teaching profession, however, it was estimated that about 60 per cent actually became teachers. In other words, the number of those certified to teach biology probably exceeded the number of those available as teachers.

Individual states are attempting to solve their problems some of which appear to be common to all. Georgia has appointed a Science-Mathematics Committee designed to work toward raising the standard for high school science teachers and to make specific recommendations to colleges submitting approved programs. In Alabama certification requirements were changed in 1953, and among other changes, science for all applicants was increased from 6 semester hours to 12 semester hours. This may encourage college students to major or minor in science since they will be required to take 12 hours of science anyway. In Alabama the certification requirements call for a major or minor in science, rather than in any one of the sciences.

This major in the new regulations was increased from 24 to 30 semester hours. In general, there appears to be a lack of professional leadership in biology through science organizations, although some states are gaining ground in this way.

The Georgia Academy of Science, through sponsorship of a Junior Academy, has attempted to strengthen and encourage better teaching in all the sciences. An active program of district organizations of science teachers has been carried out. Science fairs have been held in a few of the districts, culminating in an Annual State Fair. Annual participation in the National Talent Search has been promoted. In 1953 the organization, Research Society of America, with a chapter in The Communicable Disease Center of Atlanta, established a series of awards with adequate recognition for high school students in biology.

Science workshops and clinics have been held at the universities where practical problems of in-service teachers are discussed. The Atlanta Area Teachers' Education Service, sponsored by Carnegie grants for the advancement of teaching, has been helpful in aiding teachers. Members of the National Association of Biology Teachers and of the National Science Teachers Association have been active in stimulating interest in science in the Georgia secondary schools.

The general viewpoint of school people seems to be that the primary need of the high school is for satisfactorily educated science teachers—teachers with special competence in biology and sufficient knowledge of the others to provide appropriate science experiences for youth. The primary need of the high school teacher is for a college program which trains this type of teacher.

The teacher has a valuable, and very often untapped source of help in the various agencies in his own state. This help includes not only publications, films and the like, but also highly trained technical people employed by Public Health Departments; Plant Boards; Forestry, Game and Fish Departments, who are eager to help a teacher. These people not only have excellent scientific background training, but are at work in the field on community problems. But too often, instead of writing for specific material on a subject, or better still, for cooperation in planning meaningful experiences in resource use, the teachers and students write letters to the agencies asking only for "Everything you have about conservation."

The intelligent use of services offered by the agencies can be one of the best devices to lead the student not only to understand his environment, but also his responsibilities to it.

Summary by ROSE E. FLEMING

Participants on a Field Trip at the University Farm

PART III Problems Related to the Teaching of Biology

Section A

Teaching High School Biology

1. *What do high school biology teachers need to know about the growth and development of students in order to develop an effective biology course which will take into account individual differences, needs, interests, and abilities?*

COMMENT: Biology teachers not only teach biology; they teach it to students. Teachers can teach students better as they understand students better. It behooves every high school biology teacher, therefore, to know a good deal about the students he teaches.

Among the important principles biology teachers need to know and apply in the area of human growth and development are the following:

a. Learning results from interaction between the individual and his environment.
b. Learning is effective only if the materials and concepts are suitable to the maturity of the learner.
c. Other factors being equal, a first-hand learning experience is more effective than a vicarious one.
d. Research evidence indicates that emotional factors have a strong influence on the rate of learning. As one participant put it: "We learn not what we are taught, but how we react to what we are taught."
e. Teacher-student relationships are as important as techniques of teaching. At the very heart of the learning situation is the teacher himself.

The Conference also endorsed the proposal that college biology teachers, too, might profitably learn and incorporate into their teaching some of the modern concepts concerning human growth and development.

RECOMMENDATIONS: To help biology teachers attain necessary understanding regarding human growth and development and individual differences the Conference recommended:

a. That pre-service training include: human growth and development, genetics, psychology (particularly adolescent psychology), group dynamics, curriculum, the human life cycle, and an understanding of emotional stability and sex physiology.
b. The use of cumulative student records concerning mental maturity, subject matter backgrounds, health records, aptitudes, vocational and avocational ambitions, and the like.
c. In-service training in the area of human growth and development.
    1) Local workshops led by college or university teams.
    2) Local workshops in which faculties work cooperatively toward the improvement of instruction (with or without consultants).

2. *What should be the objectives of a secondary school biology course designed to meet the needs and interests of individual students?*

COMMENT: The teacher and students together should determine the specific objectives of a particular high school biology course. One participant pointed out that "The objectives of the course are not valid until they become the objectives of the students."

High school biology objectives should be both general and local in character. They should embrace both principles of biology and local applications.

RECOMMENDATIONS: The Conference recommended:

a. That as minimum essentials, the objectives of the secondary school biology course should provide all students with:

1) An understanding of the basic principles of biology (e.g., photosynthesis, living processes, evolution, inheritance with change, ecological relationships, et cetera) which are essential to effective living in modern society.
2) An understanding of themselves and of the human life cycle: birth, growth, maturity, old age, death.
3) An understanding of how the organisms and physical environment in a given situation form a community with many complex interrelationships. This understanding should form a basis for value judgments applicable in conservation practices, resource utilization, sanitation, and other situations involving social implications.
4) An understanding of how they can use biology in later life and even contribute to the field of biology. Since this may be the only contact with biology as a course, the secondary school biology teacher has a special responsibility in this regard.
5) An understanding of scientific methods and attitudes through experiences in the biology course.
6) A positive approach to physical and mental health.
7) Avocational interests and appreciations related to living things.

b. That in order to implement these objectives and apply them on an individual basis the following principles and/or techniques, among others, be used:
1) The course should be characterized by active rather than passive participation. This principle is predicated on a flexible program that has variety of content, procedures, and materials.
2) The course materials should provide for a wide range of content and a wide range of reading abilities among students.
3) A variety of teaching methods should be employed in order to reach all students.
4) Provision should be made for individual projects and research.
5) Resource people (e.g., county agents, county and state health officers, college and university scientists, and others) should be used to define and analyze problems of significance.
6) The program of the talented should be enriched. Superior students may be enlisted in the help of weaker students.
7) High school biology teachers should help individual students outside of school hours.
8) Student hobbies in biology should be encouraged.

3. *How can biology be integrated into the total program of the secondary school and into the lives of high school students?*

COMMENT: Integration cannot be assumed. The mere placement of one block of subject matter alongside another block does not constitute unification into a new whole.

Knowledge assuredly is not self-integrating. If integration is to take place both teacher and student must work at it—seriously.

RECOMMENDATIONS: In order that biology may be integrated into the total secondary school program and into the lives of high school students the Conference recommended:

a. That biology teachers have a general knowledge of other areas and that other teachers have a general knowledge of biology.
b. That the objectives of the biology course contribute significantly to the general objectives of the school.
c. That democratic administration characterize the secondary school.
d. That situations be created which will encourage individual, small group, and class projects to culminate in assembly programs and other school activities. These projects may be extended into intra-school and inter-school fairs, Junior Academy of Science exhibits, and similar activities.

e. That inter-departmental planning be encouraged.

f. That students be given an opportunity to apply in other classes what they have learned in biology. Illustrative of the ways in which biology may be integrated with other secondary school subjects are the following:

1) Use biological information in English themes.
2) Use biological data in formulating curves and graphs in mathematics courses.
3) Evaluate health problems, natural resources, and agricultural productivity in social science courses.
4) Study the derivation of biological terms in language courses.
5) Speak on biological topics in speech classes.
6) Use plant and animal forms and patterns of structure in art work.
7) Use the facts of human reproduction in relation to family life and social living.
8) Use knowledge of human physiology in physical education.
9) Apply in home economics classes knowledge of biology concerning the selection, care, and use of foods.

4. *How can instruction in biology (especially field work and laboratory experiences with living materials) be used to develop in secondary school students the methods, approaches, and attitudes of scientists?*

COMMENT: Scientific methods and attitudes find many applications, not only in science but also in many other fields of human experience. One participant, a professional educator, pointed out that "All teachers—not just those who teach the sciences—should stress scientific methods, approaches, and attitudes in their teaching." Another conferee, a well-known botanist, however, cautioned, "But we should realize that scientific methods do not apply to everything. They do not help us much, for instance, in certain political and social situations or in determining whether a painting or a piece of music is good. We must beware lest we oversell scientific methods."

The position of the Conference seemed to be this. Scientific methods, approaches, and attitudes find a wide range of applications. They should be used whenever appropriate. They do not, however, cover the whole of human knowledge and understanding.

RECOMMENDATIONS: The Conference recommended that biology instruction be so oriented that it will develop in high school students scientific methods, approaches, and attitudes through any or all or any combination of the following devices:

a. By the example of the teacher who, himself, uses the methods, approaches, and attitudes of scientists.
b. By reference to the classics of science and the manner in which classical scientists attacked their problems.
c. By encouraging students to find out directly, through study and/or observation, how scientists work.
d. By providing opportunities for students to participate in individual and/or group investigations, sharing their interests and findings.
e. By work based on observations of living things and/or laboratory experiments, nature trails, camp experiences, collections of living things, home gardening projects, and the like.
f. By encouraging and helping students to study problems and carry on projects which are important to them and to their community.
g. By direct instruction in scientific methods, approaches, and attitudes in classroom discussions and observational or experimental work.
h. By placing emphasis upon the use of genuine experimentation in securing answers to questions raised in the minds of students through skillful teaching.
i. By encouraging students to report the results of individual experimentation to their fellow students.
j. By field study of zonation and succession in various ecological habitats.

Through such experiences students are led to see that distribution is determined by multiple variables.

k. By training students in the precise use of language as one of the goals of the course. For example, words like geotropism or adaptation often erroneously imply an understanding of mechanisms.

l. By teaching cause-effect relationships. High school students frequently come into biology classes with anthropomorphic and teleological beliefs. These can and should be replaced by scientific methods, approaches, and attitudes.

m. By the use of a variety of valid scientific methods.

n. By cooperating with and working in such activities as the Junior Academy of Science and the Science Talent Search.

5. *How can secondary school biology teachers develop appropriate textual and instructional materials to meet the varying needs of individual students?*

COMMENT: The quality of textual and instructional materials is a matter of major concern to the conscientious biology teacher. He is ever on the lookout for new and better texts and teaching materials for he knows that, in considerable measure, they will determine the effectiveness of the teaching and learning which goes on in his classroom.

RECOMMENDATIONS: The Conference recommended that secondary school biology teachers develop appropriate textual and instructional materials (including library materials) in any or all or any combination of the following ways:

a. By enlisting the aid of expert biologists, librarians, educators, textbook specialists, and multi-sensory specialists.

b. By accumulating educational, industrial, and governmental pamphlets; multi-sensory aids; living and preserved materials; library books; periodicals; and a vertical file of magazine and newspaper articles, pictures, and feature stories.

c. By making home-made equipment, charts, models, slides, permanent collections and demonstrations, and other instructional materials.

d. By accumulating lists of local biota, their locations, and the uses to which they can be put in high school biology teaching.

e. By compiling a list of local resource people who can assist in classroom and out-of-class activities.

f. By developing, with the aid of well-prepared consultants, resource guides which will include the following:
   1) The general plan of the course.
   2) The objectives of the course.
   3) Suitable textual and library references.
   4) Suitable publications of source materials.
   5) Pertinent visual aids.
   6) Statement of problems to be raised in each unit.
   7) Statement of desired student responses.
   8) Suggested testing and evaluation procedures to measure the attainment of objectives.

6. *How can biology teachers be prepared to assume the multiple responsibilities of a small high school?*

COMMENT: This question resolves itself into two parts: pre-service training and in-service training. Inasmuch as the first part of this problem is considered under the teacher training section of this report it will not be treated fully here. Three points, however, should be made:

a. Few if any teachers *plan* to teach in small high schools. However, they frequently begin their teaching careers in small high schools.

b. The good biology teacher will automatically be qualified to teach high school general science since the good biology teacher must necessarily know a good deal about the related sciences. As indicated in another section of this report, the Conference recommended substantial amounts of chemistry,

physics, mathematics, and earth science in the training of the high school biology teacher.

c. The teaching of more than one science (i.e., more than biology) in high school is not without advantages. By teaching more than one science integration among the sciences is facilitated. Moreover, there is likely to be better teaching in one field of science if the teacher has an understanding of other related fields.

On one point the Conference was especially sensitive: the problem of the high school science teacher whose major interest is not in science. The Conference found no advantages in this situation: in fact, insofar as science teaching is concerned it is deplorable. Through local and state effort this situation should be ameliorated, reduced, and in time eliminated. The Conference strongly urged the elimination of science teachers whose major interest is in non-science fields.

RECOMMENDATIONS: The Conference recommended that biology teachers who must assume multiple responsibilities in small high schools consider the implementation of any or all or any combination of the following suggestions:

a. *Teach four instead of five classes or sections.* This will allow some free time for conferences, the handling of laboratory materials and equipment, and other necessary activities. Industrial arts teachers, vocational agriculture teachers, and a number of other high school teachers already enjoy the consideration of four instead of five classes or sections. The Conference felt the same privilege should be accorded science teachers.
b. *Alternate courses.* For example, in a small high school chemistry might be offered one year and physics the next.
c. *Use an integrated physical science course.* In a small high school such a course could take the place of separate courses in chemistry and physics.
d. *Use student assistants.* Student assistants can be very helpful. If possible, they should be paid for services.
e. *Secure ample storage space.* This will prevent cluttering in the multiple-purpose classroom.
f. *Use more demonstrations.* In considerable measure demonstrations can be made to substitute effectively for individual laboratory work.
g. *Operate a science current events file.* Such a file will do much to keep the science courses alive. The file should be maintained by both teacher and students.
h. *Use free and low-cost materials.* There is a generous supply of these materials. Many of them are of excellent quality.
i. *Use the human, natural, and social resources of the community.* Every community has these resources. The resourceful science teacher will use them.
j. *Schedule classes carefully.* Avoid repeated preparations of the same laboratory materials and demonstrations wherever possible.

7. *What constitutes an appropriate program of post-baccalaureate in-service training for secondary school teachers of biology?*

COMMENT: Pre-service training is not adequate for a lifetime of effective biology teaching. Continuous self improvement—i.e., in-service training—is essential if the high school biology teacher is to retain and increase his effectiveness in the classroom.

On one point concerning in-service training the Conference took a strong position. That had to do with appropriate graduate study for high school biology teachers. Not only should colleges and universities offer a wider variety of biology courses in the summer session in order that in-service teachers may take advantage of them; they should also, with the aid of certification agencies, explore the advisability of offering for teachers introductory courses at an appropriate level of difficulty, such courses to carry appropriate credit which will apply toward certification requirements. A participating graduate dean from a well-known university seemed to express the

feelings of the Conference when he summarized the matter this way: "If the students in a class are *graduate* students, appropriate graduate work can be offered even if it is introductory in character."

RECOMMENDATIONS: The Conference recommended as appropriate post baccalaureate in-service activities any or all or any combination of the following:

a. Graduate study in biology, related sciences, science education, or professional education according to the needs of the individual teacher. (See "COMMENT" above.)
b. Appropriate individual study of scientific and professional literature. The professional library should include among other materials professional books and journals, research reports, pamphlets, reference works, maps, and films.
c. Travel, especially travel to regions illustrating significantly different biological phenomena.
d. Contacts with college and university laboratories, greenhouses, museums, experimental farms, libraries, and other facilities.
e. Participation in local and state-wide, teacher-planned, in-service programs built around common school programs and problems related to the teaching of biology.
f. Use of well-prepared consultants from colleges, universities, industrial and social agencies, state departments of education, and other governmental agencies.
g. Conferences, workshops, professional meetings, and intra-school and inter-school teacher visitations.
h. Participation in professional and scientific organizations at the local, state, regional, and/or national levels.
i. Participation in biological and/or science education research.

8. *How can adequate and appropriate space be made available to the secondary school biology teacher?*

COMMENT: Insofar as possible and practicable all high school science classrooms should be used exclusively for science classes. If, in emergencies, the room must be used for other purposes, classes should be scheduled which will neither disturb experiments in progress nor require the putting away of equipment which will have to be used again a short time later.

When remodeling old school buildings or constructing new ones consideration should be given to the special space needs related to the teaching of secondary school biology. Careful planning is required. For individuals concerned with biology (science) space needs the publication *School Facilities for Science Instruction* received much favorable comment and commendation. This publication is distributed by the National Science Teachers Association, 1201 Sixteenth St., N.W., Washington 6, D. C.

RECOMMENDATIONS: The Conference recommended that the following factors be considered when biology teaching space is being designed:

a. That biology teachers, science supervisors, citizens, and if necessary, out-of-town and/or out-of-state specialists assist the architects in planning the biology (science) rooms.
b. That the following principles be incorporated into the plans for the biology (science) rooms:
    1) Plan multi-purpose rooms instead of separate lecture and laboratory rooms.
    2) Remember that multi-purpose science rooms must be larger than ordinary classrooms.
    3) Provide for flexibility in room use.
    4) Install fixed furniture around the walls of the rooms with movable furniture in the center.
    5) Provide for the rooms to be darkened when audio-visual aids are being used. (In warm climates air-conditioning is highly desirable.)
    6) Provide accessory rooms which may be used for storage, projects, and the like.
    7) Plan for the biology rooms to be on the first floor of the building.

CHART OF SPECIFICATIONS (Sample)

ACHIEVEMENT IN BIOLOGICAL SCIENCE AS EVIDENCED BY

OBJECTIVES / CONTENT	DEMONSTRATION OF		ABILITY TO		
	A Knowledge of Facts, Concepts, and Principles	An Understanding of Facts, Concepts, and Principles	Interpret Data Analysis Interpolation Extrapolation	Recognize and Solve Problems Evaluate Hypotheses	Appraise Real Situations that have Biological Implications
INTRODUCTION					
CHARACTERISTICS COMMON TO LIVING ORGANISMS					
MAINTENANCE OF THE INDIVIDUAL					
Nutrition					
Respiration					
Transportation					
Excretion					
Coordination and Adjustment					
Nervous System					
Endocrine System					
MAINTENANCE OF THE SPECIES					
Reproduction					
Heredity					
HISTORY OF LIFE ON THE EARTH					
Geol. & Evolution					
INTERRELATIONSHIPS					
Ecology					
Parasitism & Disease					
Conservation					
Population Problems and Eugenics					

8) Provide space for experimental work and for the growth and care of plants and animals.

9. *How can testing and evaluation, based upon the objectives of the biology course, be improved?*

COMMENT: Evaluation is intimately bound up with teaching. High level evaluation procedures, therefore, can function well only when they are proceeded by high level instruction. Both teaching and evaluation should receive their direction and impetus from well-defined objectives. If biology is well taught as a science instead of from an authoritarian approach, students should gain a wide range of experience in experimental techniques and scientific concepts. Examinations embodying these techniques and concepts should be the natural outgrowth of teaching directed toward scientific methods and the objectives of the course. If we teach for these outcomes we should evaluate the outcomes of our teaching.

High school biology should involve a great deal more than memorization of facts. Factual regurgitation on paper-and-pencil tests, therefore, will not be enough. A variety of evaluative techniques is necessary. Several approaches to evaluation are suggested in the recommendations which follow.

RECOMMENDATIONS: As means of improving testing and evaluation in high school biology the Conference recommended:

a. That all tests and other evaluative procedures be geared to the objectives stated in the overall plan for the course.
b. That, in addition to facts, high school biology examinations include experiences in understanding and interpreting biological principles, problem solving, interpretation of biological data, evaluating hypotheses in the light of evidence gained from observation or controlled experimentation, understanding cause-effect relationships, and appraisal of situations that have biological implications and significance.
c. That unstructured as well as structured or objective-type examinations be used in the evaluation program.
d. That the evaluation program include examinations using specimens and experiments.
e. That examinations requiring organizational procedures (i.e., essay examinations) be used primarily during the term rather than at the end of the term. Such examinations can be used, among other purposes, in developing composition skills.
f. That structured or objective-type examinations be used primarily in the final evaluation at the end of the term. Examinations of this type have many advantages (wide sampling, quick scoring, and the like), especially when large groups of students are to be tested.
g. That a chart of specifications be developed to serve as a guide in the construction of objective-type examinations. Such a chart will insure an appropriate distribution of items with regard to both content and objectives. (See Fig. 1, *Chart of Specifications*, p. 41).
h. That, in addition to examinations, other evaluative devices be used. These devices may include laboratory and field work, performance ratings, anecdotal records, controlled observations, interest notations, statements made by students, behavior changes observed, conferences, and/or other procedures. All have their places in the total evaluation of student progress.
i. That students participate in the evaluative process through self-appraisal. If properly encouraged and guided by the teacher, students can be highly effective in estimating their own progress.

Summary by W. HUGH STICKLER

Section B
The Teacher Training Program

10. *What constitutes a balanced program for the training of high school biology teachers? What experiences—subject matter courses, appropriate field and laboratory experiences, professional education courses—should be included in such a program?*

COMMENT: The Conference recognized that any recommendation for a balanced program will leave much to be desired if the teacher is to be prepared in four years. It was agreed, however, that a realistic view of the high school teaching situation as it exists now and will exist for some time to come required the Conference to think in terms of a four-year program.

RECOMMENDATIONS: In order to provide the best possible preparation in a four-year program, the Conference recommended that the prospective high school biology teacher have:

a. A college major (i.e., a minimum of 24 semester hours) in the biological sciences, to include one year of general biology, or equivalent courses in general botany and general zoology (incorporating the subject matter areas treated in Part I—morphology, taxonomy, physiology and health, ecology and conservation, heredity and development, evolution and paleontology), with at least one-third of the total content devoted to plant

science. Course work beyond the first year should include field studies.

b. One year of chemistry, with laboratory work. It was recommended that this work include organic chemistry as it applies to living things.
c. One year of physics, with laboratory work.
d. One half-year of earth science.
e. One year of mathematics.
f. Education courses to meet state certification requirements, with a course in methods of teaching high school biology strongly recommended. Professional education courses should include experiences in the following areas:
   1) The nature of the learning process.
   2) Human growth and development.
   3) Professional laboratory experiences.
   4) Internship.
   5) Group dynamics.
   6) The secondary school program (the role of the school in society, curriculum, history and philosophy of education, and the like).
   7) Testing and evaluation.
g. Appropriate general education courses (humanities, social sciences, and communication skills) required of other high school teachers.

The above were recommended as minimum requirements in the training of an effective high school biology teacher. The Conference recommended that, whenever possible, courses allowing for certification in other sciences or related fields should be taken. (Specific courses and fields must, of course, be planned in the light of minimum certification requirements of the state involved.)

11. *How can specialists in biology and professional educators be brought into a better working relationship in the training of biology teachers?*

COMMENT: Effective high school biology teaching requires a teacher with a broad background of understandings in: (1) the subject matter of biology, and (2) the areas of adolescent growth and development, objectives of the total high school program and of the biology course, methods of working with high school boys and girls, and techniques of evaluating student progress. Traditionally, the implementation of the former has been the function of the specialist in biology, while the latter has been the province of the professional educator. Too often each has operated independently, leaving the prospective teachers with the difficult task of integrating their teaching. Such integration would better result from cooperation of the specialist in biology and the professional educator. Integration in turn would result from the establishment of better working relationships. Biologists, like other arts and science specialists, too often criticize professional educators without becoming informed regarding the problems of education and without any effort to join forces with the educators. Biologists and educators can produce the best possible teachers only by working together.

RECOMMENDATIONS: In order to bring about effective working relations between biologists and educators, the Conference recommended:

a. Work conferences at the local, state, regional, and national levels in which specialists in biology and professional educators can talk out their problems in face-to-face meetings.
b. Giving biology departments the responsibility of providing competent members of their staff to teach the "methods" courses in biology which commonly carry education credit.
c. Encouraging the specialist in biology to observe and work with student teachers of biology who received their subject matter training in his (the specialists) college classes.
d. Drawing upon the background of experience of the specialist in biology in the planning of education courses, particularly as they deal with such problems as human physiology and genetics.
e. Active participation in teacher training of both educationist and science specialist. This participation involves cooperative decisions concerning:
   1. Certification requirements.
   2. Advising students.

3. Evaluation of program and outcomes.
4. Evaluation of the teaching in both areas.
5. Science specialist leading field trips and participating in other activities involving the education student.

f. Making provisions for and encouraging the observance of college biology classes by professional educators and of college education classes by specialists in biology, with the end in view of eliminating unnecessary duplication and making courses more effective.

g. Providing for greater mutual action by educators and biologists in promoting and working with Junior Academies of Science and similar organizations of high school students interested in science.

h. Encouraging schools of Education and State Departments of Education to consult with competent biologists in planning the biology subject matter requirements necessary for graduation and certification of the high school teacher.

i. Provision for exchange teaching assignments between biologists and educators.[1]

j. Having biologists and educators make joint appearances on radio and television programs.

12. *How can colleges and universities contribute effectively to the in-service Education of biology teachers? Particularly, how can colleges and universities provide biology teachers with appropriate subject matter courses (especially extension courses and summer school offerings) which will carry appropriate college credit and at the same time apply toward certification?*

RECOMMENDATIONS: The Conference recommended:

a. That consideration be given to the offering of a larger number of biology courses during the summer sessions; further, that institutions explore, with the aid and cooperation of certification agencies, the possibilities of extension courses where facilities and demand make them feasible.

b. That annual one-week conferences be operated for biology teachers giving:
   1) Help in using simple materials for experiments.
   2) Demonstrations of new types of experimental work.
   3) Additional background and new developments.

c. That appropriate credit be given to teachers for courses at any level. It is recognized that graduate students with teaching experience should not be in classes with college freshmen, but this does not preclude graduate credit for fields, e.g., general botany, which have traditionally been organized for presentation at the freshman level.

d. That special subject matter courses be designed for the teacher and that these courses be scheduled at appropriate times.

e. That full residence credit be given for workshops and work conferences which are comparable in length and quality to standard courses.

f. That opportunity be provided for outstanding high school teachers to assist in the teaching of college courses, so that theory and practice may be more closely related.

g. That consideration be given to the possibility of a special degree which will recognize the breadth of training needed by the teacher.

h. That each science specialist be encouraged to feel intensely the responsibility to work with his colleagues in the high school on every possible occasion.

i. That scientists prepare articles for journals designed for teachers.

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[1] *One discussion group recommended joint appointments in the Departments of Biology and Education. It was recognized that such a plan could be highly effective, but that adjustment of teaching load, red tape, allocation of responsibility and various administrative difficulties would preclude such a plan in most institutions.*

j. That science camps be operated for students and teachers.

k. That provision be made for substituting suitable extra course work, projects, and activities for the thesis requirement for the master's degree.

13. *How can colleges and universities effectively recruit and select secondary school and college teachers of biology?*

RECOMMENDATIONS: The Conference recommended recruiting and selecting secondary school and college biology teachers:

a. By assigning the best teachers on the staff to teach the introductory college courses in biology.

b. By encouraging research on the part of college teachers so that undergraduate students may become imbued with the desire to do creative work.

c. By working toward salaries more nearly comparable to those in industry, government agencies, and other fields of science. Professional status, advancement and salary of college teachers should be based as much on teaching success as on products of research.

d. By acquainting capable college graduates with the variety of scholarships and loans which are available for graduate study, with special reference to students in smaller colleges.

e. By increasing emphasis on meetings at which competition in biology projects and problems at the high school and undergraduate college levels is emphasized, such as science fairs, science camps, and local science programs.

f. By urging universities and colleges to increase their stipends for graduate assistantships in science.

g. By soliciting from individuals and industries interested in promoting science at the undergraduate college level, scholarships in biology available to above-average high school graduates.

h. By a more extensive use of aptitude tests in identifying and selecting potential teachers.

i. By adjusting academic loads of college teachers to allow for extra-college contacts.

j. By distribution of attractive brochures, with frequent revision, on the teaching of biology as a career.

14. *How can colleges and university teachers of biology improve their educational philosophy and their teaching techniques?*

COMMENT: The college or university teacher is obligated to contribute to the advancement of knowledge through research, to teach, and to participate in the solution of regional and university problems related to his science. Any training of the college teacher must take full cognizance of these obligations.

The college teacher may extend his knowledge of educational problems through library research, study, and exchange of information with his colleagues in other institutions. The potential college teacher may be best provided the essential background in education, philosophy, history, and techniques through seminars and apprentice teaching under the direction of biologists.

RECOMMENDATIONS: The Conference recommended:

a. That colleges and universities recognize and appropriately reward the good teacher through advancements in rank and salary.

b. That joint seminars covering topics of mutual interest be scheduled for students and teachers of both biology and professional education. It was emphasized that in many institutions all the necessary machinery for such seminars already exists and that all that is necessary is a desire to use facilities already available.

c. That teacher training institutions work as closely as possible with state departments of instruction, since these departments can only implement what is wanted by the institutions and by the public.

Summary by John Breukelman

Section C

Role of the State Departments in the Improvement of High School Biology Teaching

15. *How shall we deal with the problems of provisional and temporary certification for biology teachers who do not meet minimum requirements?*

COMMENT: This problem arises out of the acute shortage of qualified biology teachers; it points up sharply the responsibility of teachers in secondary schools and colleges, of national societies, to interest many more capable college and high school students in biology teaching.

Higher, but not too rigid certification requirements, based on the kind of training outlined in the report on college teaching should be adopted in science as they are in such fields as vocational agriculture. This might help to improve the salary status of science teachers and to attract competent people into the field.

RECOMMENDATIONS: The Conference recommended:

a. That provisional certificates be issued only when the local superintendent can certify the lack of a qualified teacher, and that holders of such certificates be required to become qualified in as short a time as possible by summer school work.

   That provisional certificates be issued on a one-year basis and that they be renewable upon presentation of evidence of satisfactory progress towards meeting full certification requirements. If a choice must be made between a person trained in biology without professional courses in education and one with a certificate but no biology training, the former would be preferred.

b. That programs be set up within the school or local system, in collaboration with nearby colleges and state science supervisors, for the immediate and continuing in-service training of teachers with provisional and temporary certificates.

c. That teachers be encouraged to enroll in formal courses selected from the teacher training program on which full certification is based.

d. That teachers be encouraged to participate in an active in-service teacher training program in the local system, sponsored by the local administration, the State Department of Education, and the colleges.

16. *How can the program in public school biology be cooperatively planned so as to use effectively local units, college officials and teachers and the state departments of education (especially science consultants and certifying officers)?*

RECOMMENDATIONS: The Conference recommended:

That the program in public school biology should be cooperatively planned by the establishment in each state of a continuing articulation and planning committee, composed of representatives from these fields:

a. High school administrators.
b. College and university administrators.
c. High school teachers fully certified in biology.
d. College and university teachers in the biological sciences and in education.
e. Science consultants on the state level.
f. The supervisory and certification divisions of the State Department of Education.
g. The State Academy of Science.

That the functions of this committee be to:

a. Identify problems concerned with certification, teacher education, the program of study at all levels, or with a combination and extension of these problems.
b. Furnish leadership in helping the State Department of Education, the public schools, and institutions of

higher education in obtaining an effective solution to these problems.

c. Encourage and disseminate pertinent information concerning the importance of instruction in biology.

d. Assist in the recruitment of biology teachers.

e. Encourage the school administrators to study the need for greater cooperative action and seek their help in implementing recommendations made by the committee.

17. *What is the role of the State Departments of Education in fostering in-service training which will result in the improvement of biology teaching?*

RECOMMENDATIONS: The Conference recommended:

That the State Department employ well-qualified science coordinators, advisors or consultants who have had high school experience and are trained in both science and education, to consult with science teachers in high schools and to implement a program of cooperation between college scientists and high school teachers.

That the need for a state science coordinator, consultant or advisor be made known by the science teachers to the State Department and the various agencies having policy control over the state department.

That State Department consultants help by:

a. Assisting in coordination of services of the State Department, the colleges, and the local systems in activities conducive to improvement of instruction in science.

b. Assisting in setting up committees for cooperatively developing curricular materials and share these with all high school science teachers.

c. Providing a means of communicating to all teachers information on best teaching practices, and other information which will add to the quality of teaching.

Encouraging greater exchange of information between science specialists and teachers of high school science through pre- and post-school planning conferences, regional meetings of science teachers, and at the county and local school level.

d. Encouraging classroom teachers through in-service programs to become involved in classroom research for the improvement of teaching so that the gap between "what teachers know" and "what teachers do" in the classroom will be closed.

e. Encouraging existing science associations and organizations to keep all science teachers on the high school level up-to-date on information and research; and encouraging the formation of new associations where needed to assist in such work.

f. Encouraging colleges and universities having approved programs for teacher training to provide adequate subject matter workshops and specific courses projected primarily for teachers in subject matter areas and for which credit will be given in continuing certification.

g. Encouraging the colleges to make available services of subject matter personnel as consultants to schools in their vicinity.

h. Assisting the state committee recommended above (composed of both high school and college teachers) to advise, consult and plan for recruitment, selection, motivation, and the up-grading of biology teachers.

i. Encouraging all local school administrators to provide for in-service teacher training conference for biology teachers prior to the opening of school, during the year, and for post-school conferences, for purposes of evaluating, planning, and re-evaluating the biology program. Consultants for such in-service conferences should include personnel from the State Department concerned with teacher training and improvement of instruction in the area of biology, and personnel from appropriate departments of the colleges which prepare biology teachers.

18. *What role can the State Department of Education play in insuring adequately prepared teachers in secondary school biology? What can be done to prevent individuals with little or no training in biology from teaching secondary school biology courses?*

RECOMMENDATIONS: The Conference recommended:

a. That State Departments of Education adhere to certification requirements which will insure training such as that indicated in the recommendation for college training and that content areas be adequately represented on commissions that establish certification requirements.

b. That the science consultants in the State Departments actively supervise the science teaching in high schools.

c. That the State Department refuse to certify a person unless he has had college courses in biology which adequately cover the areas of a high school biology course.

d. That the State Department of Education cooperate with the colleges in setting up approved programs for teachers which would give broad training in science and mathematics in addition to a balanced general education, and which will enable the teacher in a small school to teach in more than one area.

e. That certification requirements be raised to the level of the training as recommended earlier. These requirements should list the subjects considered minimal in chemistry, physics, mathematics and other sciences, and in professional education, not merely the number of credit hours. This will insure that biology certificates, for example, go to people with broad and fundamental training, and would exclude those with a number of credits in a narrowly limited area of biology.

19. *To what extent can and should the State Department of Education assist in the allocation of full-time (hour-for-hour) teaching credit for instruction in the biology laboratory?*

COMMENT: There is only one measure of teaching credit: the number of hours spent with students or preparing classroom materials. Credit for class hours should be the same whether those hours are spent in recitation, laboratory, shop, or field. This should become the general rule.

RECOMMENDATIONS: The Conference recommended:

That the appropriate agency or persons in state departments and colleges assist in obtaining an hour-for-hour allocation of full-time teaching credit for instructors in high school and college science laboratories.

20. *How can the State Department of Education aid in the recruitment, selection, motivation, and up-grading of high school and college biology teachers?*

RECOMMENDATIONS: The Conference recommended:

a. The establishment of salary scales adequate to attract and retain qualified teachers in the profession.

b. The establishment of suitable retirement benefits.

c. The maintenance of active in-service training by:
   1) Conducting well-planned workshops.
   2) Providing competent consultants.
   3) Cooperating with conservation, agricultural and other state agencies in producing suitable pamphlets in biological subjects.
   4) Promoting adequate communication on problems and techniques among biology teachers.

d. The establishment and maintenance of a research staff to evaluate and suggest improvements in methodology.

e. The encouragement of democratic administration because this is a crucial factor in retainment and retainment is a part of recruitment.

f. The encouragement of and assistance in obtaining the best classroom in-

struction possible as this is most important in recruitment of future teachers.

g. The encouragement of local communities to insist on the best biology teaching obtainable.

h. The encouragement of and utilization of the efforts of the many scientific and educational groups interested in and working on recruitment of biology teachers and biologists.

i. Encouraging deans, department heads and advisors to present the teaching profession as an attractive career opportunity to biology majors.

Summary by: RICHARD L. WEAVER

PART IV Summary of State Programs of Action for Implementing the Conclusions and Recommendations of the Southeastern Work Conference on Biology Teaching

The State teams represented in this conference assumed responsibility and leadership for the following programs of action:

A. Dissemination of information concerning this conference:

1. News release to state and local papers.
2. Summary articles in state education association journals and papers.
3. Distribution of copies of conference summary report to the following persons and groups:
   a. State Superintendent of Public Instruction and other key personnel in the State Department of Education.
   b. Deans and heads of departments of biological sciences in all institutions of higher learning.
   c. Members of Advisory Committees and Councils on Teacher Education.
   d. Heads of state academies of sciences.
   e. Heads of science section of education associations.
   f. All high school science teachers, college instructors in science, and high school principals.
4. Face-to-face (oral) presentation and discussion of conference report by state team or representatives with the following individuals and/or groups:
   a. State Superintendent of Public Instruction.
   b. Director of Teacher Education and Certification.
   c. Science section of State Education Association fall conferences.
   d. Advisory Committee on Teacher Education.
   e. Organization of School Administrators.
   f. District education conferences.
   g. Home faculty or staff of each conferee.

B. Implementation of Recommendations:

1. Request the State Department of Education to employ or to designate a science consultant to work with college and high school teachers and instructors of science.
2. Encourage college biology teachers to become participating members of the science section of the state education association.
3. Request the director of teacher education and certification in the state department of education to work with teacher education institutions in an effort to get heads of science departments to review and to revise their offerings for a major in biology in light of the proposals made at this conference.

4. Suggest that science staffs of all teacher education institutions attempt to work cooperatively in determining the courses offered for the prospective science teacher.
5. Promote one or two day system-wide workshop for science teachers during the pre-school conference period.
6. Determine the true picture of the supply and demand of adequately trained biology teachers in the state to be used on basis for further recruitment.
7. Encourage high school science teachers to organize school science clubs and become members of the junior academies of sciences.
8. Stimulate high school clubs to use lecturers and other services offered by the senior academies.
9. Urge the Councils on Teacher Education and the State Board of Education to adopt the program of teacher education and certification of biology teachers proposed by this conference.
10. Hold a state-wide conference on biology teaching similar in representation, plan of work, and procedures to this Southeastern Conference for the following purposes:

    a. To study the problems in science teaching with particular attention to those of biology teaching.
    b. To initiate publication of a periodical high school science bulletin, and to decide upon types of materials to be included.
    c. To formulate proposals to be made to the Division of Teacher Education and Certification.
    d. To study ways to strengthen teacher education programs in the area of science to the end that a more adequate number of prospective teachers will be attracted to the program and to the end, ultimately, that the quality of science teaching made available to all students will be of such quality and vital enough to make a difference in their lives.
    e. To implement, in general, conclusions and recommendations resulting from this Southeastern Work Conference.

Summary by LOUISE COMBS
State Department of Education
Frankfort, Ky.

The National Science Foundation Conference Program

Keith R. Kelson
Education in the Sciences Program
National Science Foundation

It would be presumptuous indeed for me to attempt to tell you much about the National Science Foundation. I have been associated with the Foundation only a few short weeks. But it is especially because of this short period of association that I am most happy to be here for I have been able to learn first-hand, and from the ultimate source, of some of the problems that confront the educational community. These are among the problems of direct concern to the Foundation. Moreover, I have a deep and abiding personal interest in the science classroom and if in our deliberations I have sometimes played the role of the devil's advocate too vigorously, be assured that my intent was constructive and my attitude sympathetic. Let me also express my sincere appreciation for being invited to participate in your discussions. I have thereby learned the full pungency of the opinions expressed here as I could have no other way.

At the beginning of the conference I had the pleasure of outlining to you some of the objectives of the National Science Foundation. I mentioned briefly some of the devices we were employing to achieve those objectives. Even so, I am sure that our general interests and specifically our interest in this conference were not clear to some of you. The Foundation is broadly charged with the responsibility of developing a national policy directed toward increasing the scientific potential of the country within the limits imposed by the necessity of securing optimum balance between strictly scientific and other human activities. More than by any other aspect our era in history is characterized by the impact of science on human affairs. This is forcibly brought to our attention daily; a single glance at a newspaper suffices to emphasize the point. Further, that same newspaper will direct your attention all too clearly to that gigantic tug-o-war between the major ideologies which form the restless background of our lives. Science by its very nature has been cast in a leading role in this milieu of strife. But our supply of scientists is dwindling both in quantity and quality at the very time it should be burgeoning. The problem is no longer a theoretical one. We are approaching a potential crisis at headlong speed—a crisis whose outcome we must regard as critical.

One of the most important areas where help is needed and needed badly is that increasingly significant structure of our society, the high school science classroom. Although potential scientists may be born, they will come to naught but for the ministrations of skilled teachers working in suitable conditions—thus the Foundation's interest in your work here. I hope you understand that the Foundation is operationally and conceptually a part of the educational and scientific community it serves. We of the Foundation staff consider ourselves necessarily part and parcel of your activities and would stoutly resist any impetus in another direction. But how, specifically, can we take our proper place in the operations to produce more and better scientists?

We of the Foundation's staff are all keenly aware of our individual limitations. We cannot, for example, immediately foresee all of the problems inherent in our responsibility, much less all of the answers. Yet, to solve a problem—and especially to *assist* in the solution—it is first necessary to understand clearly what the problem is. One of the most effective ways the Foundation has of learning what problems exist and which of these are most troublesome is to support conferences such as this one where informed and thinking people representing diverse viewpoints and backgrounds can collectively produce a concise statement of problems. Had you gone no further here than the second stage of the

agenda—that of outlining the problems—even then you would have made a substantial contribution. But you have done more, much more. You have produced solutions for some problems and have outlined ways in which others might be solved. Most of you were unaware as you worked here that your efforts were of greater importance than the regional nature of the conference would indicate. You know now, I trust, that owing to the nature of your National Science Foundation each of you has played a direct role in influencing the development of a national science policy and the means of implementing it. I did not wish at the beginning of this conference to belabor this point unduly—nor do I wish to belabor it now—nonetheless it is true.

Explicitly, or in some cases implicitly, the record of this conference contains certain recommendations. I assure you that these will receive our careful study to determine whether the Foundation, among others, should seek to expand its activities along certain lines and whether some of our present activities are good, bad, or indifferent from your point of view. Briefly, the conference record may offer us new insights and certainly will help us measure our program. Specifically, we shall re-examine our concepts and operations directly relevant to the improvement of high school science teaching in the light of your findings. For example, you regard as very desirable those summer institutes designed to up-date inservice teachers. This is gratifying because we are already supporting such institutes to the extent we are able with our limited means. It is clear, also, that we should continue to seek the informed opinions and recommendations of responsible persons. We are surer than ever that conferences such as we have supported here are a useful means of securing that information. And in the strictest sense such support is self-support because you are an integral and necessary part of us. Furthermore, we like it that way.

Finally, let me say for the benefit of those who were unable to attend the entire conference, one important result achieved here has not yet been mentioned. One way to describe this is merely to call attention to the many corpses of apathy and personal prejudice that lie moribund on the floors of committee rooms. May they rest in peace!

Participants at the Southeastern Work Conference (see next page for identification)

National Association of Biology Teachers

SOUTHEASTERN WORK CONFERENCE ON BIOLOGY TEACHING

University of Florida

August 28-September 6, 1954

Participants

STAFF

1. Richard L. Weaver, *Co-Director*, Associate Professor of Conservation, University of Michigan, Ann Arbor, Michigan
2. Samuel Meyer, *Co-Director*, Head, Florida State University, Tallahassee, Florida Oceanographic Institute, Florida State University, Tallahassee, Florida

** 3. N. E. Bingham, Professor of Science Education, University of Florida, Gainesville, Florida

** 4. George Jeffers, Professor of Biology, Longwood College, Farmville, Virginia

** 5. W. Hugh Stickler, Director of Educational Research and Service, Florida State University, Tallahassee, Fla.

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**10. Brother Charles, *President-Elect, NABT*, Professor of Biology, St. Mary's College, Winona, Minnesota

*11. Ruth A. Dodge, *NABT Representative on the AIBS Governing Board*, Biology Teacher, Emma Willard School, Troy, New York

12. S. E. Duncan, State Supervisor of Negro High Schools, State Department of Public Instruction, Raleigh, N. C.

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**14. Howard M. Phillips, Dean of the Graduate School, Emory University, Emory University, Georgia

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*16. Paul Webster, High School Teacher, *Secretary, NABT*, Bryan, Ohio

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17. Maurice Ahrens, Professor of Education, University of Florida, Gainesville, Florida
18. Jesse T. Anderson, State Superintendent of Education, Department of Education, Columbia, South Carolina
19. C. F. Byers, Assistant Dean, College of Arts and Sciences, Department of Biology, University of Florida, Gainesville, Florida
20. L. M. Lester, Director, Division of Instruction, State Department of Education, Atlanta, Georgia
21. Sam H. Moorer, Director, Division of Instructional Field Services, Department of Education, Tallahassee, Florida
22. W. J. Terry, State Superintendent, Department of Education, Montgomery, Alabama
23. J. B. White, Dean, College of Education, University of Florida, Gainesville, Florida

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24. Mrs. Blanche Evans Dean, Biology Teacher, Woodlawn High School, Birmingham, Alabama
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26. Mrs. G. W. Smith, High School Teacher, Greene County High School, Eutaw, Alabama
27. W. T. Wilks, Professor of Science, State Teachers College, Troy, Alabama

**28. Father Patrick H. Yancey, Chairman, Department of Biology, Spring Hill, Alabama

Florida

29. Alice Baker, Research Associate, Physiology Department, Florida State University, Tallahassee, Florida
30. W. E. Combs, Supervisor of Secondary Schools for Negroes, State Department of Education, Tallahassee, Florida
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*36. Beth Schultz, Graduate Assistant, University of Florida, Gainesville, Florida

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Georgia

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41. W. W. E. Blanchet, Administrative Dean, Professor of Physical Science, The Fort Valley State College, Fort Valley, Georgia

**42. Mrs. Gordon Brown, Science Coordinator, Board of Education, City Hall, Atlanta, Georgia

43. Mrs. Jerry Lowe, Supervising Teacher of High School Science, Demonstration School, Georgia State College for Women, Milledgeville, Georgia

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49. Herbert P. Riley, Head, Department of Botany, University of Kentucky, Lexington, Kentucky
50. E. D. Whedbee, Jr., Biology Teachers, Central High School, Louisville, Kentucky

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51. Mrs. Helen Boyd, Head, Science Department, Covington High School, Covington, Louisiana
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53. W. G. Erwin, Head, Biology Department, Northwestern State College, Nachitoches, Louisiana
54. J. W. Lee, Biology Department, Southern University, Baton Rouge, Louisiana

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55. R. L. Caylor, Professor of Biology, Delta State College, Cleveland, Mississippi
56. Mrs. Rose Fleming, Information and Education Assistant, Mississippi Game and Fish Commission, Jackson, Mississippi
57. John M. Frazier, Head, Division of Conservation and Natural Resources, Mississippi Southern College, Hattiesburg, Mississippi
58. Herman R. Nixon, Assistant Professor of Biology, Jackson College, Jackson, Mississippi
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North Carolina

61. Ray Derrick, Head, Biology Department, Appalachian State Teachers College, Boone, North Carolina
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63. Mrs. Hilda S. Halliburton, High School Teacher, Canton High School, Canton, North Carolina
64. Marcellus C. Miller, Phillips High School, Biology Teacher, Battleboro, North Carolina
65. Hollis Rogers, Assistant Professor of Botany, Woman's College, University of North Carolina, Greensboro, North Carolina
66. Henry Shannon, Advisor Science and Mathematics, North Carolina Department of Public Instruction, Raleigh, North Carolina

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67. Elizabeth Cardwell, Biology Teacher, Eau Claire High School, Columbia, South Carolina
68. Edward Ferguson, Jr., Head, Department of Biology, South Carolina State College, Orangeburg, South Carolina
69. Harry Freeman, Assistant Professor of Biology, University of South Carolina, Columbia, South Carolina
70. Margaret Hess, Head, Department of Biology, Winthrop College, Rock Hill, South Carolina
71. Joel T. Kelly, Assistant High School Supervisor, State Department of Education, Columbia, South Carolina
72. H. Irene Wilburn, Chairman, Science Department, Parker High School, Greenville, South Carolina

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Virginia

80. Samuella Crim, High School Teacher, Broadway High School, Broadway, Virginia
81. Susie V. Floyd, Newport News High School, Newport News, Virginia
82. Horton Hobbs, Associate Professor of Biology, University of Virginia, Charlottesville, Virginia
83. Charles E. Packard, Associate Professor of Biology, Randolph-Macon College, Ashland, Virginia
84. J. V. Parnell, Professor of Biology, Virginia State College, Petersburg, Virginia
85. Percy H. Warren, Dean and Professor of Biology, Madison College, Harrisonburg, Virginia

Non-Regional Delegates

86. John A. Behnke, Associate Administrative Secretary, AAAS, Washington, D. C.
87. F. L. Campbell, Executive Director, AIBS, National Research Council, Washington, D. C.
88. Ralph E. Cleland, Head, Department of Botany and Dean of the Graduate School, Indiana University, Bloomington, Indiana
89. Keith R. Kelson, National Science Foundation, Washington, D. C.
90. George O. Lee, Biology Teacher, Panama Canal Zone Junior College and Balboa High School, Balboa Heights, Canal Zone
91. Clarence Nelson, Associate Professor of Biology, Michigan State College, East Lansing, Michigan
*92. Richard Paulson, (Staff Assistant, Committee on Educational Policies, Division of Biology and Agriculture, National Research Council, Washington, D. C.) Assistant Professor of Zoology, University of Chicago, Chicago, Illinois
93. Loren C. Petry, Professor of Botany, Cornell University, Ithaca, New York
94. Richard Wareham, Science Editor, D. C. Heath Co., Boston, Massachusetts

**Chairman of Work Group
*Recorder of Work Group